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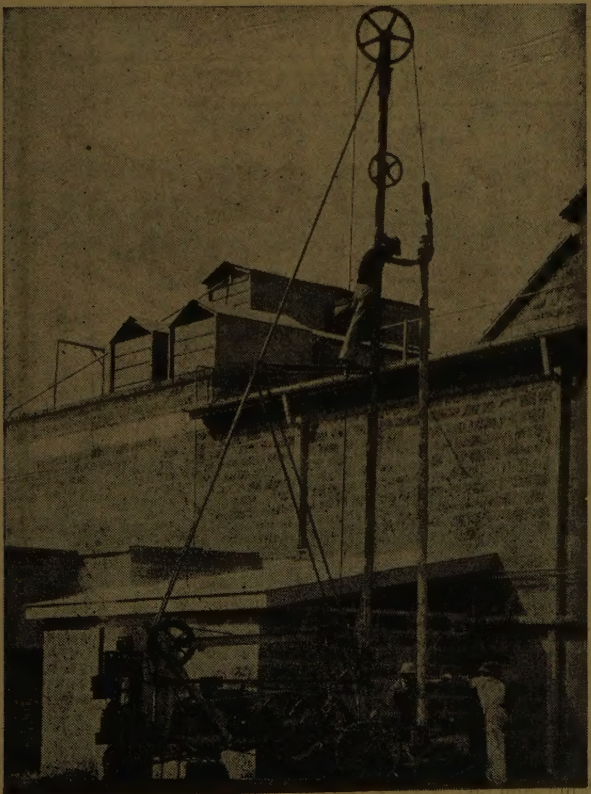

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THE
EAST AFRICAN AGRICULTURAL JOURNAL

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Readers are reminded that all agricultural inquiries, whether they relate to articles in the *Journal* or not, should be addressed to the local Director of Agriculture, and not to Amani.

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THE NAIROBI RESEARCH CONFERENCE

We publish in this issue a report of the proceedings of the Technical Session of an agricultural research conference which was held in Nairobi on 29th, 30th and 31st July. Conference reports do not make light reading, but the subjects discussed are of interest to farmers and officials in East Africa, and the opinions expressed show the present trend of thought in the field of agriculural research.

The Organization Session, which preceded the Technical Session and was under the chairmanship of Sir George Sandford, Chief Secretary to the East African Governors' Conference, dealt mainly with the establishment of an East African Agricultural and Forestry Research Organization. The term "research organization", which now replaces the terms "research institute" and "research station" is no mere play on words; it indicates the change of attitude which has come about in scientific circles, largely owing to wartime experience. It is now agreed that research can best be carried on by groups of workers, possibly belonging to several professions, who can examine a problem from widely differing angles. The object of setting up an agricultural and forestry research organization in East Africa is to allow better contact between research workers, and also to ensure that field officers will play a bigger part in keeping the practical viewpoint to the fore. It is essential that full appreciation of each other's difficulties should be maintained between theoretical investigators and those who are working out practical improvements: if their efforts are combined they can throw light on many difficult problems, but working separately they are severely handicapped.

Under the new research scheme much of the work will be carried out in field stations, adjacent to or on part of departmental experiment stations, and the headquarters in Kenya will house only those whose work must be centralized. In this way it will be possible to have the best practical advice whenever it is required: local knowledge plays an important part in solving agricultural problems, and close contact between specialist and field officers will greatly assist progress.

The direction of widely scattered research groups requires many qualities in addition to outstanding academic ability, and it is fortunate that Dr. B. A. Keen, F.R.S., has accepted the directorship of the new organization. In addition to his brilliant researches in soil physics, he was for many years Assistant Director of Rothamsted Experimental Station, and in his wide experience in India and the Middle East he has been faced with problems similar to those of East Africa.

That the Director has been appointed before the new organization is actually in existence is a point of great advantage, in that he has had an opportunity to review the agricultural problems in East Africa before final decisions have been taken on the work which will be given priority in the opening stages of the scheme. Progress will probably be slow at first, since shortage of staff and of building materials will delay the setting up of new headquarters near Nairobi; the first task will therefore be to make the best possible use of those facilities which are available at the moment. A start is now being made by forming a team to work on fertilizer experiments with food crops, in order to find out how the productivity of the soil can best be increased. The large phosphate deposits in Uganda could provide an almost unlimited supply of phosphatic fertilizers, but it is not certain how, when, and where these should be applied, and deficiencies of other plant nutrients, particularly nitrogen, are likely to complicate the issue. A skeleton staff is already available for this project, since the Cinchona Research Organization, under the directorship of Mr. L. R. Doughty, has recently been closed down, and its staff have been transferred to this fertilizer experiments team.

The East African Agricultural and Forestry Research Organization will be one of the "common services" administered by the East African High Commission, which comes into being on 1st January, 1948. The Director will have his office in Nairobi, but the technical

staff will be based on Amani until the new headquarters are ready for occupation. Any disadvantages of this arrangement are offset by the fact that laboratories, houses, and equipment are immediately available and there will be no delay in starting the scheme.

The work of the Technical Session of the Conference was speeded up by the prior circulation of notes on the main subjects, but in spite of this it was realized that there would not be sufficient time to deal adequately with the wide range of subjects. Accordingly, the Chairman, Dr. E. B. Worthington, suggested that Study Groups should be formed, in order that more detailed consideration could be given to selected subjects. The opportunities thus afforded for officers from different territories to discuss their problems were greatly appreciated, and did much to foster the spirit of collaboration which will be vital to the success of the new research plans.

Considerable emphasis was laid on the necessity for further work on live stock, a subject which concerns both veterinary and agricultural sciences. The place of cattle in agricultural practice is important in districts where mixed farming is possible, and the agricultural officers present were unanimous in stressing the need for intensive work on this subject. On the other hand, the health of the animal is primarily the concern of the veterinary profession, and the East African Veterinary Research Organization, which has recently been established, will be responsible for this line of research. There is also a wide field of work on this subject which cannot be clearly divided into agricultural and veterinary sections, but there was no doubt that the departments concerned were willing to collaborate on any common ground.

Another subject which stimulated discussion was the use of ecological zones as a basis for planning research, and it was suggested that ecological survey should have high priority, particularly in relation to pasture research. Political and administrative boundaries so frequently dominate the mental view that their artificiality is often overlooked, and East Africa is outstanding in its wide range of climate and vegetation. Northern Rhodesia has already adopted the ecological survey as a foundation for agricultural development, and it is clear that fuller consideration of the ecological zones of other parts of East Africa is required.

The need for investigation of methods of mechanized farming was also discussed, and it was agreed that this would be an important function of the new research organization. Fears and doubts have been expressed on the consequences of bringing the plough into native African agriculture, and there is no doubt that it would be dangerous to do so without strict control of land use, which, however, must soon be applied in Africa, even with present methods of cultivation. It seems likely that mechanization, if it is based on scientific trial and applied under firm administrative direction, would change the face of Africa for the better. But the consequences, as well as the advantages, of mechanized farming must be studied in field trials before large-scale mechanization of native farming can be encouraged, and in this we are fortunate in having the Groundnut Scheme from which to learn lessons. The native will become tractor-conscious when he sees groundnuts produced on an enormous scale by mechanical means, but small-scale experiments, followed by cautious application in large-scale trials, are necessary before we can know how to control mechanized native farming for its own good.

The East African Agricultural Journal also came in for discussion at the Technical Session, and it was agreed that it should continue to include articles on veterinary science and forestry, since the time is not yet ripe for separate journals on these subjects. There is, however, a certain amount of criticism that the articles tend to be too long and to include too much technical detail, and the suggestion was adopted that more emphasis should be laid on short articles and notes. Yet it must be remembered that this Journal is a useful medium for recording the results of experimental work in East Africa, often of interest in temperate as well as tropical climates. For this purpose, conclusions must be supported by adequate evidence, and some technical detail is therefore unavoidable, although it is true that many articles could be cut shorter without losing any of their value. Short articles and notes are always welcome, and we hope that the numbers of these will increase.

D. W. D.

ERRATUM

In this Journal, Volume XIII, No. 1, July, 1947, page 27, the author's name should read C. G. Glegg, Dip. Hort. (Wye). It is regretted that Mr. Glegg's name was incorrectly spelt Clegg.

AGRICULTURAL RESEARCH CONFERENCE

NAIROBI, 29th–31st JULY, 1947

PROCEEDINGS OF THE TECHNICAL SESSION

PRESENT

Chairman—
Dr. E. B. Worthington, Scientific Secretary, E.A. Governors' Conference.

Colonial Office—
Dr. H. H. Storey, F.R.S., Secretary, Colonial Agricultural Research Committee.

E.A. Agricultural and Forestry Research Organization—
Dr. B. A. Keen, F.R.S., Director.

E.A. Governors' Conference—
Dr. M. H. French, Controller of Hides and Skins.

E.A. Veterinary Research Organization—
Mr. W. B. C. Danks, Deputy Director (Production).

E.A. Agricultural Research Institute—
Dr. D. W. Duthie, Acting Director.
Mr. L. R. Doughty, Director, Cinchona Research.
Mr. P. J. Greenway, Systematic Botanist.

E.A. Industrial Research Board—
Mr. H. B. Stent, Acting Chairman.

Empire Cotton Growing Corporation—
Dr. F. R. Parnell, Director, Cotton Research.
Mr A. N. Prentice, Scientific Officer.

Imperial Chemical Industries—
Mr. R. V. Holme.

United Africa Company—
Dr. A. H. Bunting, Chief Scientific Officer.

Kenya—
Major F. W. Cavendish-Bentinck, C.M.G., Member for Agriculture and Natural Resources.
Mr. D. L. Blunt, C.M.G., Director of Agriculture.
Mr. E. Beaumont, Director of Veterinary Services.
Mr. J. C. Rammell, Conservator of Forests.
Mr. W. O. Sunman, Deputy Director of Agriculture.
Mr. V. A. Beckley, O.B.E., M.C., Senior Agricultural Chemist.
Mr. A. R. Melville, Senior Entomologist.
Mr. N. Humphrey, Senior Agricultural Officer.
Mr. E. W. Gaddum, Agricultural Officer (Pyrethrum).
Mr. G. H. Gethin-Jones, Soil Chemist.
Mr. H. C. Thorpe, Senior Plant Breeder, Soil Research.
Mr. A. C. Maher, Senior Soil Conservation Officer.
Mr. D. C. Edwards, Senior Agricultural Officer, i/c Grassland Experiments.
Dr. A. C. Pereira, Agricultural Chemist, Coffee Research.
Mr. R. W. Rayner, Plant Physiologist Coffee Research.

Uganda—
Mr. A. B. Killick, Director of Agriculture.
Mr. W. L. S. MacIntosh, Director of Veterinary Services.
Dr. W. J. Eggeling, Conservator of Forests.
Mr. R. K. Kerkham, Agricultural Officer.
Dr. A. Griffith, Senior Chemist.

Tanganyika—
Mr. R. W. R. Miller, C.M.G., Director of Agriculture.
Mr. N. R. Reid, Director designate of Veterinary Services.
Mr. L. G. T. Wigg, Acting Conservator of Forests.
Mr. W. A. Burns, Deputy Director of Veterinary Services.
Mr. G. W. Lock, O.B.E., Senior Agricultural Officer.
Mr. H. J. van Rensburg, Pasture Research Officer.
Mr. F. Hughes, Utilization Officer.

Zanzibar—
Mr. O. S. Swainson, Acting Director of Agriculture.
Mr. W. E. Calton, Government Chemist.

Nyasaland—
Mr. C. B. Garnett, Acting Director of Agriculture.

AGENDA

1. The need for ecological, soil, land utilization and social surveys on an inter-territorial basis.

2. Biological and physical conditions in tropical and sub-tropical soils.
   (*a*) The organic-matter cycle and soil fertility.
   (*b*) Soil structure in relation to moisture, etc., and plant growth.

3. The fundamental basis of mixed farming.
   (*a*) Animal husbandry and "pasture" (fodder) research.
   (*b*) "Pasture" improvement in relation to grazing and management and nutritive value.
   (*c*) Effect of different systems of pasture management on yield of arable crops.
   (*d*) Problems of leguminous crops.

4. Plant food status with special reference to the action of inorganic and organic fertilizers.

5. Mechanized farming and the need for investigation.

6. East African Agricultural and Forestry Journal.

7. A "Flora" of East Africa.

In opening the meeting, Dr. Worthington pointed out that the main reason for holding this Technical Session was to give opportunities for members to express their opinions on problems which were likely to be investigated by the new research organization. Collaboration between agricultural, veterinary, and forestry research organizations and territorial departments could best be assured by discussions between the officers concerned, in order that they should obtain a wider view of

the work involved. Notes on the subjects had been prepared and circulated, but it was clear that there would not be sufficient time for full discussion at this meeting. Accordingly, he suggested that subjects should be selected for further discussion on the following day by Study Groups, membership of which would be open to all who were interested in the particular subject. He emphasized that the results of discussions on these technical subjects would be of great assistance to the Director of E.A.A. and F.R.O. in framing his research programme.

ITEM 1

The Need for Ecological, Soil, Land Utilization and Social Surveys on an Inter-territorial Basis.

Note by E. B. Worthington

All will agree that surveys of subjects mentioned in this item are highly desirable, and often essential, before development plans for particular areas can be effectively prepared. It is quite certain, however, that the available effort for such surveys will not be adequate to meet all the needs during the next ten years, so that the question of priorities in the areas to be studied, and in the subjects of study, becomes important.

Whereas general surveys of whole countries, or the whole region, must take their place, leading to maps of soil types, vegetation, land use and the like, it is suggested that the greatest immediate benefit will generally accrue by concentrating a large part of the available effort on relatively small areas which are scheduled for intensive development. Such areas are those selected for settlement schemes to take surplus population in Kenya, "pilot" schemes in Uganda, special Province and District schemes such as Sumumuland, Mbulu District and Uluguru mountains in Tanganyika.

Some types of survey, notably land utilization and social surveys, are of importance to many branches of development in addition to agriculture and forestry. The question arises, therefore, how far they should come within the scope of E.A.A. and F.R.O. Referring back to Paper No. 1 of the Conference "Regional Organization of Research in East Africa", it is clar that land utilization surveys for particular development schemes should be undertaken by Development (or Operational) Research Teams proposed in paragraph (8) (*h*), each consisting of individuals selected from several Research Organizations. There may also be room in such teams for professional geographers of the kind who have been responsible for the land utilization surveys of Great Britain.

The problems posed below by Mr. Humphrey indicate, moreover, that development research teams should often, if not always, include professional sociologists. The supply of sociologists suitably trained is likely to be a major difficulty for many years to come.

The Sociological Aspects of African Agricultural Problems

Note by N. Humphrey

(A) The Need for Sociological Research

Agricultural reform in the native lands must depend in large measure on the goodwill and co-operation of the African peoples. It is essential, therefore, that due weight should be given to the social aspects of African agricultural problems, when land utilization surveys are being made and development plans prepared. Proposals framed without due regard to their social implications are unlikely to evoke co-operation and may, indeed, arouse bitter opposition. Again, reforms must be preceded and accompanied by educational campaigns and these are much more likely to be effective if they have been framed with a proper conception of the social factors involved.

In illustration of the above paragraph, the following examples from Kenya may be cited:—

(*a*) In all cases where cattle are concerned, it is most important that the real nature of the problem should be understood before proposals for stock limitation and control are put into effect. Over-grazing may not necessarily be due to people owning too many cattle, which is the usual interpretation of the word "over-stocking". It may be due, as is primarily the case in Ukambani, to over-population. In such cases destocking without population relief must lead to intense opposition as the African sees what to him is his basis of security being taken away from him. Again, over-grazing may be due to lack of balance in the farming system which in its turn may be due to population pressure as well as to out-moded farming methods.

(*b*) The place that cattle fill in tribal life needs study. It has been suggested, for instance, that "bride price" is the chief

obstacle to stock limitation and that its abolition is the solution to the problem. This is almost certainly a grave over-simplification, though clearly a consideration of "bride price" should form part of any inquiries that are made.

Over-grazing, also, may be affected by factors *outside* the particular district being considered. Thus stock limitation in the Kikuyu lands cannot safely be discussed unless due consideration is given to the problem of squatter stock. Recent opposition to dipping and culling in part of the Kikuyu country might not have been so serious had not the scheme coincided with the eviction of squatter stock from neighbouring European areas. In such cases the ordinary African peasant becomes more easily influenced by political agitators with their misrepresentation of Government's motives.

Sociological considerations are involved when pastoral tribes begin to turn towards agriculture. In Kenya the Nandi and the Kipsigis are examples where the advice of the sociologist might be of great value in devising plans to guide the tribes towards mixed farming instead of towards the form of monoculture to which they are inclining to-day.

A final example can be taken from North Kavirondo, where suitable mixed farming technique for part of the District has been developed at the Bukura agricultural station but where little progress can be recorded in getting Africans to adopt the new methods. The evidence suggests that sociological considerations are largely responsible for the apathy displayed and modifications based on such considerations may make the demonstrations more acceptable to African opinion.

(B) The Need for Co-ordination on an Inter-territorial Basis.

Given that the need for sociological research is accepted, then there are a number of reasons why it should be co-ordinated on an inter-territorial basis. In the first place, there is the obvious value to individual workers in being able to exchange ideas with, and receive information from, other workers in the same field. In the second, lack of co-ordination may lead to the failure of a worker to realize the significance of a particular line of investigation. A case of this nature came to the notice of the writer quite recently. Thirdly, it is considered that great value attaches to comparative studies of such matters as trends in land tenure and the evolution of indigenous agricultural customs. It is, of course, recognized that there is very great diversity in customs from tribe to tribe, but it is significant how frequently modern conditions produce similar effects in widely separated areas. Still another reason for co-ordination and the exchange of information lies in the need for sympathetic education of the African in modern farming practices. Here, also a wide knowledge of indigenous customs and the ways in which they are changing is likely to be of the greatest help to those who are trying to teach better farming methods.

A few examples, illustrating the potential value of comparative studies, are appended.

(*a*) *Land Tenure.*—There is evidence in Kenya that amongst the Bantu tribes increasing population pressure, more perhaps than any other factor, causes land tenure customs to change in the direction of freehold tenure. Thus it is worthy of note that the right to "sell" land outright is claimed by peoples of such densely populated, but widely separated, areas as Kiambu, Maragoli and Teita. It is clearly of the great interest to know whether similar trends are found in other territories and amongst non-Bantu tribes. Comparative studies might give valuable information as to the way such changes proceed.

(*b*) *Over-population.*—The social effects of over-population of rural areas require study under diverse conditions.

(*c*) *Agricultural systems* amongst various tribes vary greatly in their degree of complexity. Studies of the causes of such variations are likely to produce results that would certainly be of considerable value from the educational point of view.

(*d*) *Trends of pastoral tribes towards agriculture.*—The cases of the Nandi and Kipsigis in Kenya have been mentioned above. Similar trends must be showing themselves in other parts of East Africa and comparative studies could not fail to produce information of the greatest value.

Further examples could be cited but enough have been mentioned to support the arguments of the previous paragraphs. It is suggested, therefore, that a strong case has been made for the co-ordination of research into the sociological aspects of African agriculture problems on the inter-territorial basis.

SUMMARY OF DISCUSSION

In opening the discussion, the Chairman, Dr. Worthington, reminded members that the Social Science Research Council is already employing several sociologists in East Africa, and he was not certain to what extent social surveys would come into the programme of E.A.A. and F.R.O. Mr. Humphrey said that the African, although he is conservative in his outlook, does change his customs, particularly under pressure of population, and he gave as example the trend from communal land tenure towards individual holdings, either freehold or under tenancy, in some of the more progressive districts of Kenya. Sociological studies are required in order to predict the effect on tribal customs of changes in environment, such as that which would result from extensive mechanization of native farming. By carrying out these studies on an inter-territorial basis the workers would be able to obtain a clearer picture of their own area by comparing their observations with those of their co-workers in other districts.

Mr. Miller called attention to the very large amount of work necessary for surveying even a small area, and suggested that two or three small schemes should be selected for trial, in order that the most efficient methods of survey, using mainly African staff, could be developed. Dr. Duthie agreed with this, and pointed out that survey work requires special training and experience. He suggested that a survey unit should be set up as part of E.A.A. and F.R.O., particularly for soil and ecological surveys, but to include also any others which may be advisable.

Dr. Keen pointed out that experience in other countries had shown that the results of land-use surveys could not be applied unless powers of persuasion, practically amounting to compulsion, were available.

As further discussion was considered advisable, a Study Group was formed, with Mr. Humphrey as Convener.

REPORT OF THE STUDY GROUP

Vegetation and Climate.—There is much information on vegetation available in the territories, but it lacks correlation, which would enable a preliminary vegetation map for the region to be prepared. Valuable supplementary information could be provided by an examination of the vegetation types at each meteorological station. A transect should be run through different types of vegetation, for instance in the Mount Kenya area from the desert to the mountain. Meteorological stations should be established in each vegetation community along such a transect in order to link climate with vegetation.

Soils.—Soil reconnaissance, as distinct from systematic soil survey, should have a high priority in the East African Agricultural and Forestry Research Organization programme. The reconnaissance would elaborate the East African soil map; it would do much to define soil types pedologically, and would dovetail with the study of vegetation types. The Geological Departments should be asked for information about the petrology of the different formations which are described and mapped.

Land Utilization.—Officers in the different territories require the help of a statistician at headquarters to advise on suitable sampling technique.

Sociological Investigation.—This is recognized as of extreme importance, and the E.A.A. and F.R.O. will need to establish close liaison with the Social Science Faculty at Makerere when formed.

ITEM 2

BIOLOGICAL AND PHYSICAL CONDITIONS IN TROPICAL AND SUB-TROPICAL SOILS WITH SPECIAL REFERENCE TO INVESTIGATIONS ON THE SEMI-ARID AREAS.

Note by J. Glover

One of the most important problems in East Africa is that of drought. Over three-quarter million people depend on the vagaries of the rain in semi-arid areas, and of these more than half a million live in the 36,000 sq. miles of the Central Province. They are grain farmers and keep cattle, so there is a basis for a form of mixed farming there if they can be safeguarded against all but the worst of droughts. That agriculture above subsistence level can be practised in semi-arid regions has been amply demonstrated in the hot, dry south-western Great Plains of the U.S.A. These areas have been developed by the selection and breeding of drought-resistant cereals and pasture grasses as well as by the adoption of good dry-farming practices. I submit, therefore, that a study of the semi-arid Central Province of Tanganyika would be extremely valuable to the agricultural development of East Africa. The knowledge gained there would not only be of benefit to the present half-million inhabitants but would be a good guide to similar problems in the relatively better-favoured (from the standpoint of water supplies) neighbouring

Lake and Western Provinces which support half the population of Tanganyika, as well as to the dry areas of neighbouring East African territories.

The whole problem of these dry areas is—What happens to the rain and how can it be used most efficiently for the betterment of agriculture? To answer this would require, among others, studies of the following:—

(*a*) The breeding or selection of drought-resisting or quickly maturing cereals and of drought-resistant grasses for the cattle ranges.

(*b*) The gains and losses of water by the soil under different plants and different methods of crop husbandry.

(*c*) Dry-farming methods and their application to local conditions.

(*d*) Pasture management for moisture conservation.

(*e*) Fertilizers, e.g. phosphate, which may promote root growth and thus enable greater areas of soil to be tapped for moisture.

I therefore suggest that a dry-land experiment station should be established under E.A.A. and F.R.O. for this purpose.

Summary of Discussion

Dr. Bunting said that the utilization of areas with low rainfall was of vital interest to the Groundnut Scheme, and emphasized that problems of the semi-arid areas must be studied in the field from all points of view, otherwise the results would be difficult to interpret. Suitable statistical designs for field experiments would be required in order to answer several questions at the same time, such as, is there a link between phosphate and drought resistance, and what are the effects of organic matter, inorganic fertilizers and soil management on soil moisture? Physical and physiological studies would play a large part in the work, but these should be carried out under a comprehensive plan. Supporting Dr. Bunting's remarks, Dr. Keen pointed out that this very important problem is one in which the research organization could most usefully collaborate with territorial departments and with commodity and non-Government stations. Mr. Reid called attention to the past and present work by the Tanganyika veterinary department on pasture problems of dry areas, and suggested that Mpwapwa might be a suitable base from which to conduct the investigations.

ITEM 2 (*a*)

The Organic Matter Cycle and Soil Fertility

Note by F. R. Parnell

Apart from soil erosion problems, concerned with keeping the soil in its place, *the* big problem facing agricultural workers in East Africa is that of maintaining fertility where it exists and of building it up over vast areas where it is at a low level. The supply of organic matter in the soil is of very great importance in that endeavour and this note deals with some of the points of interest. It is written by request, but with considerable hesitation, as the writer is a layman in the subject and can only ask questions, not supply information.

Taking the main factors determining fertility to be (*a*) available supply of plant foods and (*b*) physical condition of the soil, how are these factors affected by the organic matter content?

(*a*) We know that organic matter in the soil is directly concerned in the supply of plant foods, minerals and nitrogen, which become available as it decomposes. It forms the main reserve of nitrogen in the soil and is of particular importance in this respect. Does it also serve other useful purposes in the plant food chain; e.g., is it of value as a source of energy for nitrogen-fixing bacteria, or as a growth medium for other beneficial organisms; is it an aid to the solution of minerals not directly available, etc.?

(*b*) Abundance of organic matter has a marked effect on the physical conditions of soils, e.g. by opening up heavy soils and improving both their capacity to absorb water and their aeration, by rendering very light soils more retentive of moisture, etc. Are such physical effects of real value where the organic matter content is comparatively low, as it is in so many tropical soils? For instance, does a moderate dressing of organic manure benefit a poor soil otherwise than through the plant foods it contains?

Much more detailed knowledge is required of the whole nutrient status of soils under investigation before field experiments can be expected to throw light on these questions.

Very commonly, the fertility of a soil depends to a great extent on its organic matter content and the building up of fertility demands a permanent increase in this constituent. It is generally believed, undoubtedly with good reason in many cases, that organic matter

disappears very rapidly from tropical soils, but there appears to be little detailed knowledge on this point. The whole problem is one of great importance and merits early investigation.

Does the decomposition of organic matter, e.g. crop residues, follow the same *course* in tropical as in temperate regions, apart from the more rapid breakdown? Does it pass through the stage of "humus", more stable than the original material, in the same way, either generally or in particular conditions? Can any method of treatment, of the organic matter before application, or of the soil, be effective in slowing down the decomposition? Will different types of vegetation under which the land may be rested, and which find their way into the soil eventually, affect this issue? Is the rapid disappearance of organic matter in some cases due to consumption by termites rather than to decomposition?

Some early results from rotation experiments carried out by Peat at Ukiriguru, in the Lake Province of Tanganyika, are of considerable interest. The soil is a coarse sand derived from granite, incapable of giving any crumb structure in the ordinary sense of the term. A three-years' rest under elephant grass, partly grazed before being dug in, resulted in a 40 per cent increase of crop in the first year: pigeon pea, *Cajanus indicus*, gave a 45 per cent increase. There was *no residual effect* on the second year's crop in either case, a most disappointing result. It would appear that the whole of the organic matter accrued from the resting crops had disappeared in one season. There would be little hope of *building up* organic matter in the soil if any addition lasted only for a single season. Contrasted with the above results, however, both farm-yard manure and compost give more lasting effects. A single 5-ton dressing of either gives an increase of up to 50 per cent in the first year's crop, with a residual effect in the second and third year giving increases of up to 40 per cent and 25 per cent respectively. With heavy applications there is a definite fourth-year effect.

The interpretation is uncertain, since very little is known of the general nutrient status of the soil, an example of the necessity for such knowledge in work of this nature. If, as is suspected, the increases are mainly due to nitrogen, either the organic matter of the manures has lasted for three years, or nitrogen has persisted for this time in some other form. Is it possible that the decomposition of the farm-yard manure and compost, already partly reduced to *humus* before application, follows a different course from that of the fresh resting crop residues? If this should prove to be the case, it would be a matter of very great interest and of no little importance.

There is a possibility that termites played a part by consuming some of the crop residues. Where this happens, what becomes of the plant foods in the organic matter consumed?

Soils newly opened from bush, grass, etc., vary enormously in the time during which their fertility lasts under cultivation. Some forest soils, uncultivated possibly for centuries, are "finished" after two or three years' cultivation. Such soils must be very low in mineral plant foods, but they appear to start with a considerable amount of organic matter, which might be expected to keep them going longer. Why does it disappear so quickly? Is it in reality deficient in *quantity* to begin with, perhaps too much on the surface, or is it in a *condition* that leads to extremely rapid decomposition? Again, there are soils, often of quite light texture, which maintain their fertility for many years without being given any particular attention. They are obviously rich in plant foods, of which the nitrogen supply presumably depends on persistent organic matter. Why does it persist so long in such cases? Does it last for, possibly, twenty years or so, because of its higher initial *content*, its more stable condition, its distribution to greater depths in the soil, where *lower temperatures* prevail?

Knowledge on such questions as these will not necessarily point to direct action that can be taken, but should help towards a greater understanding of the problems involved in the building up and maintenance of fertility in tropical soils.

Summary of Discussion

In opening the discussion on this subject, Mr. Parnell summarized his note in the form of a number of questions: What happens to the organic matter in the soil? What do we know of the possibility of quite small amounts of organic matter modifying the physical soil conditions? Has organic manure any function other than those of supplying plant nutrients? Is it true that it is not possible to build up the content of soil organic matter under tropical farming conditions? Is the nature of added organic matter important? Why do some soils lose their fertility almost at once when the natural forest cover is removed,

whereas others, under similar treatment, remain fertile for many years?

Mr. Beckley supported Mr. Parnell's view that a great deal of research is necessary in this field, and suggested that a microbiologist and an organic chemist should collaborate in the work, with particular reference to the action of bacteria at low tropical altitudes, that of actinomyces at high altitudes, and the dominant function of fungi at intermediate altitudes. Dr. Griffith drew attention to the work of Geltser, in which the old concept of humus being the "residue" of plant remains is dismissed, and it is suggested that humus is formed exclusively by bacterial action, fungal action being of no importance. Geltser claims that the products of bacterial decomposition, added to the soil, are effective in crumb formation.

Mr. Gethin Jones pointed out that complex fundamental problems were involved in a study of the organic cycle in tropical soils, and suggested that research institutes in the United Kingdom should be asked to undertake investigations on some of these fundamental points. He considered that the work in East Africa should be carried out mainly in the field.

ITEM 2 (*b*)

Soil Structure in Relation to Moisture-Relationships, Nutrient-Status and Plant Growth.

Note by Ap Griffith

W. S. Martin has shown that cultivation breaks down crumb structure, and that structure is improved by a rest under grass cover, and that this effect is common to a number of grasses including annual grasses.

The existence of a good crumb structure in our heavier soils increases pore space, giving quick and easy pentration of rainfall and space to store it in. Even in Uganda, with a well distributed rainfall of 45-55 inches, there is evidence that soil moisture is sometimes a limiting factor in crop production, especially on over-cultivated slopes.

Martin further holds that the same considerations apply to air supply, since as the water is used, it must be followed by air, and repeated cultivation for the purpose of aerating soil defeats its own purpose by pulverizing crumbs and reducing pore space. The roots of a crop find difficulty in penetrating a compact powdery soil, and are confined to the moist airy top soil. This may not matter where good rainfall is received, but may lead to crop check, or even failure, in years of poor rainfall distribution. In soils of good structure, the roots are free to move downwards in search of water, and eventually draw water and food from a bigger volume of soil.

Martin has also concluded that organic manures do not improve soil structure, and, further, that experiments, both with F.Y.M. and artificials, showed little response until the introduction of the grass rotation, since when quite small dressings are giving significant increases. He puts forward the hypothesis that, with better structure, water supply and root development are improved and therefore that the plant can make better use of the nutrients available.

Linked with the question of application of manure is that of how it is applied. With the limitations of African transport facilities, it is obviously important to determine how the value of dropped manure compares with that of carted manure. Linked in turn with the effect of the animal and its products on the land is the effect of the treatments on the cattle. All these effects, including live weight gains of cattle, are being worked out at Serere. At the present stage, it is not possible to analyse the results statistically, but indications to date are that applied F.Y.M. gives better results, but it is unlikely that the increase of yields would compensate for the extra cost of application. The whole time kraal-kept cattle, however, did not do quite so well as those allowed to graze. This series of experiments is regarded as of fundamental importance.

For future lines of work, I would suggest the following:—

(1) Further investigations of clay and organic carbon contents of the different fractions for various soils.

(2) I consider that Martin's conclusion that organic manures have no effect on soil structure is an extremely important one. He (I think) considers that the decay of organic residues is too rapid and complete to allow for any lasting effect upon the soil. If this is so, I think it indicates that more attention should be directed to (*a*) the form of the organic manure applied and (*b*) the manner in which it is applied. It appears to me difficult to accept the unorthodox implication (if such indeed is intended)

that organic manures are of no importance in determining soil structure.

(3) I think an investigation of the structural limits of (*a*) erodibility and (*b*) resistance to erosion of a soil would be profitable.

(4) It has been shown by Smith [5] that aggregates greater than 1 mm. in diameter had a greater base content than the finer material. This is a point of some interest which can readily be verified.

(5) I think the effect of soil structure on the plant-soil structure relationships needs investigation and suggest that the effect of structure on wilting point and on moisture evaporation should be determined. It is possible that soil structure may have some bearing on the controversial subject of the raising of water from lower layers. This introduces the question of to what depth of the soil an improvement in structure is desirable.

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SUMMARY OF DISCUSSION

Dr. Griffith referred to the summary of information on soil structure which was published by the Imperial Bureau of Soil Science in 1938, and suggested that the Bureau should be asked to prepare a further bulletin in order to bring the information up to date. Turning to the work on soil structure carried out by Dr. W. S. Martin in Uganda, he gave a summary of the latter's more recent conclusions, that:—

(*a*) organic manures do not improve soil structure,

(*b*) lime does not cause any water-stable aggregation of soil particles,

(*c*) cultivation causes soil deterioration,

(*d*) rest under a grass cover improves soil structure.

Dr. Griffith said that some of Dr. Martin's latest conclusions do not conform to orthodox views, and therefore much further work was necessary. He suggested three lines of work which would help to clarify the problem: firstly, a generally agreed method of determining soil crumbs is required: secondly, we should look into the stability of the crumbs, as it is obviously necessary to know what the crumbs can stand up to in the way of rainfall, exposure, and cultivation: thirdly, information should be sought on the depth to which structure can be modified and maintained, and on the effect of structural modification on run-off, evaporation and erodibility.

Mr. Holme disagreed with Dr. Martin's view that cultivation causes soil deterioration, although he would agree that incorrect cultivation does this. He suggested that a factor of importance is the length of time that rain water remains on the surface. Even in semi-arid areas a heavy shower might cause temporary water-logging of the top soil and adversely affect its biological and physical processes.

The Chairman said that Items 2, 2*a* and 2*b* should be referred to a Study Group with Mr. Beckley as Convener, although he realized that even then there would not be sufficient time for full discussion of these complex problems.

REPORT OF THE STUDY GROUP

Although Martin's technique of estimating soil structure by wet sieving gives highly dependable results with many soils, anomalous results are obtained with certain soils. *It is therefore recommended that a study of methods of determining crumb structure be made at an early date* and, if possible, a standardized method evolved, applicable to the majority of soils.

In Uganda on certain soils there is a close correlation between crumb structure and crop yield. In other cases, however, there is not such correlation. The effect may be physical, that is to say, aeration; it may be due to increased plant nutrient supply, to the water supply; or perhaps to a combination of all three. In certain cases, organic matter may have a marked physical effect, and alter the soil structure; on the other hand, the physical effect is often negligible, but the supply of plant nutrients is increased. The retention of organic matter in soils is largely affected by the micro flora and fauna of the soil which, in its turn, is affected by climatic conditions. *It is therefore recommended that the complex*

soil structure—organic matter—plant nutrient supply—water relationship merits early study which should cover various soil types and climatic conditions. This study should not be confined to the laboratory but should largely lie in the field.

Although grass covers will greatly improve the crumb structure of many soils, this structure can be quickly destroyed by improper cultivation. On the other hand, suitable cultivation can greatly improve the crumb structure of some soils. *It is recommended that a study of cultivation implements and the methods of their use be included in the programme of the East African Agricultural and Forestry Research Organization.*

ITEM 2 (*c*)

Influence of Forests on Soil Moisture, Streamflow, and Run-off

The Chairman announced that this item had been included in the agenda at the last minute, and therefore no notes had been prepared for circulation. Mr. Rammell said that Forest Officers wished to know how their sylvicultural and other practices are affecting the water conservation of the areas concerned. It seemed clear that the effects of trees, bamboo and grass would differ widely, but research was necessary in order to determine which of these would be most suitable in any particular area. Another question requiring study was whether foresters were altering the water supply of an area by replacing the natural forest of the watersheds with economic forest plantations. He gave several other examples to show how the subjects discussed under Item 2 were related to forestry practice.

The Chairman thought that it would be best to refer this important subject to a Study Group with Mr. Rammell as Convener, and their report is given below.

Report of the Study Group

It is of the greatest importance to the Forest Departments of East Africa that research should be carried out into the question of the influence of forests *vis-à-vis* other vegetational types on soil moisture, stream flow and run-off. Considerable evidence on this subject has been obtained in various parts of the world, but facts are lacking in East Africa, and it is suggested that views expressed here are opinions based only on preliminary observations with little backing from factual data.

There are the following main types of forest management and policy, regarding which research on this subject is of the utmost importance.

(*a*) Reservation of hills and the drier mountain ranges not capable of permanent cultivation or grazing, with a view to their reafforestation by natural means. The objects of this are not only to save the hills from denudation and reduction to bare rock, but also to preserve the flow of springs and to regulate run-off to the greatest extent possible.

(*b*) The conservation under forest growth of catchments, springs and river banks to regulate flow.

(*c*) The replacement of natural forest of indigenous timber, bush, bamboo, etc., by well managed plantations of indigenous and to a larger extent of exotic species, mainly Cypress. The production of large quantities of softwood timber by this method is of the greatest potential value to East Africa not only from the point of production of timber, a product of vital national importance for local consumption and export, but also from the point of view of the great financial returns which may be expected. The view has been expressed that by doing so climate and stream flow may be affected adversely.

The Professor of Forestry at Oxford has stated that he receives more inquiries from professional officers and the general public on this subject than on any other aspect of Forestry. No information can be given except in a few isolated cases where large-scale experiments have been carried out, and it is not safe to generalize from them.

Research of this nature is of urgent importance to East Africa and is eminently one for the E.A.A. and F.R.O., as it is not purely a forest problem, but one affecting many other aspects of land use. If, for instance, it should be proved that the objects envisaged in 2 (*a*) and (*b*) are not, in fact, obtained, and that the programme in (*c*) is deleterious to climate and water supply, forest policy must be largely recast.

Short Term Projects.

The most important problem so far as forestry is concerned is to gain some information on the effect of replacing natural

forest by exotic plantations. We recommend as an immediate short term policy that the following two projects be put into effect at the earliest possible moment as staff and equipment become available:—

(i) Soil moisture recording by the Bouycous block type of technique evolved by the Coffee Services Physiologist and Agricultural Chemist at the Scott Agricultural Laboratories, Nairobi.

(ii) Plant transpiration measurement by the torsion transpiration balance as developed by Henrici in South Africa.

From the first it will be possible to observe the rate of penetration of rainfall in forest cover and the rate of drying during the drought. From the second it should be possible to check whether transpiration is more or less rapid during the rainy period.

We suggest that in view of the lack of qualified staff at present consideration be given to widening the scope of soil moisture investigations which affect forests as greatly as any other crop.

ITEM 3 (*a*)

Animal Husbandry and "Pasture" (Fodder) Research

Note by D. L. Blunt

In the European farming areas Kenya has passed through the usual phases of agricultural development in a new country, including a period of single cropping, mainly with maize. The fable of the inexhaustible fertility of tropical soils held sway for many years until it was exploded by falling yields. Similarly in native areas, although the original type of farming was a conservative one, pressure of population on the land and the urge to produce the maximum cash return from cash crops changed the type of farming from a conservative one to a soil exhausting one. In each case the necessity for maximum production during the war has increased the damage. In both cases the result has been deterioration of the soil structure, the absence of an adequate soil cover at the onset of the rainy season and, as a result, serious sheet erosion with loss of top soil, insufficient moisture holding capacity of the soil that remains, and falling yields leading to complaints that there is progressive desiccation of the country, though rainfall records hardly bear this out. There is no doubt that in the case of the majority of arable soils of the country the remedy is so-called mixed farming with a rotational period under grass or other forage crop utilized by stock. In many cases where deterioration has gone to considerable lengths, terracing and fertilizing are necessary to hold the soil and to give sufficient fertility to enable the grass or forage crop to be established.

It is clear that the proper use of stock and the proper establishment and use of grass must be an integral part of the farming system adopted and, because of the urgent need for soil improvement, the most important part of the system. Not only is research on the breeding, feeding and management of the stock and the establishment and management of the pasture of the first importance, but the inter-action of the one on the other is inseparable from such researches and of no less practical importance. On both sides something has been accomplished, but on both sides a large field remains unexplored. In the realm of animal husbandry the Veterinary Department has made some headway in the improvement of the native zebu cattle and in that work a proper balance has been maintained between breeding and feeding. The work at present is on all too small a scale, but it is hoped that it may be expanded in the near future. European farmers have, over the last 25 years, spent much time, energy and money on the introduction and breeding of pure European breeds, but the work has suffered in many cases through the absence of a definite and stable breeding policy, and in perhaps the majority of cases too much faith has been pinned on breeding, while management and feeding have not received the attention necessary to achieve the best results. Pasture research is in its infancy and we know all too little of the potentialities of our natural herbage under varying systems of management. We have made the first steps in the direction of establishing temporary leys, but only the first steps and much more still remains to be done.

It is hoped that the Conference will in due course make recommendations for the further pursuit of researches in both these matters, researches which, it is believed, are of greater importance to the welfare of these East African Colonies than any others with the exception of fundamental researches into the structure and characteristics of soils on which researches on the grass and the animal must be largely based.

An endeavour has been made to indicate the essential inter-action between the animal

and the pasture, and it will be clear that the organization and direction of such investigations cannot be expected to achieve any satisfactory result unless they are carried on in the closest co-operation one with the other, and it is suggested that the only satisfactory organization to achieve the major object is one where the whole falls under a single direction.

ITEM 3 (*b*)

Pasture Improvement in Relation to Grazing and Management and Nutritive Value.

Note by D. C. Edwards

The main factor which controls the possibility of pasture improvement in East Africa is moisture. A considerable degree of improvement is only possible in regions of relatively high rainfall with a minimum of, say, 30 inches per annum. The greater part of the territory with which we have to deal is under conditions which permit only of extensive management, but the importance of correct grazing methods can scarcely be over-emphasized in both the moist and semi-arid regions. In the densely-populated agricultural areas of the former type, temporary pasture is an essential factor in the maintenance of soil fertility, while in the vast existing and potential areas of natural pasture the urgent necessity is to apply correct methods of utilization, in order to derive the best possible return from the land and, at the same time, to guard the vegetation against degeneration caused by improper management, which must result eventually in the loss of the soil itself.

The requirements of pasture research fall under two main heads (*a*) study of the reaction to management of natural grasslands and (*b*) experiments with individual species intended for the artificial establishment of pasture by sowing. The former requirement is general, while the latter concerns only areas where rainfall is sufficiently high for crop production, as indicated above, but under local conditions degeneration of physical structure in cultivated soil appears to be peculiarly rapid, and recovery of desirable structure is dependent upon a periodical close cover of vegetation such as pasture.

Obviously, natural grasslands can only be studied effectively and correct methods of management be devised on a regional basis. Also, the requirements of species for the artificial establishment of pastures are widely different from one climatic area to another, chiefly on account of differing temperatures associated with the varying elevation of the land masses. Further, experience has already shown that the first and main line of investigation towards obtaining such pasture plants should be that of the indigenous flora, which in East Africa presents an exceptional opportunity for the study of ecotypes of widely distributed species. It is thus apparent that both of the above lines of work must be preceded by a survey of the vegetation in order to provide the regional basis. The climatic regions are marked by the great plant communities, or "formations" in the terminology of Clements, and the survey would seek to recognize and map these communities. In Kenya this work has already been carried to the stage of providing sufficient information upon which to site the regional stations, and the significance of the communities in terms of climate is at least roughly known. In the absence of regional stations, work on the grassland associated with only one type of vegetation has so far been possible (i.e. Kikuyu grass-dominated herbage), apart from a preliminary study of grass-burning in the extensive *Acacia-Themeda* community. Some progress has also been made in experiments with individual pasture plants, and certain of the grasses have already, to a limited extent, attained practical utilization in European agriculture.

In regard to the nutritive value of pasture, it is perhaps easy to give too much weight to the chemical investigation of individual grasses at the present stage of development in East Africa. The primary requirement is determination of the correct methods of management of the various types of natural grassland and, for the agricultural regions, the provision of sufficiently persistent species which are capable of withstanding intensive grazing and of which seed supplies can be built up. Nutritive value is, after all, largely a result of growth-stage and therefore of the methods of grazing management employed. The assistance of the chemist will be required in such directions as the determination of seasonal variation of nutrients so that adjustments can be made in supplementary feeding, the investigation of the possibilities of pasture improvement through the application of mineral manures under intensive management, and the study of the effect of the grass cover upon the physical state of the soil. This is, of course, quite apart from the important matter of soil survey.

The set-up which is visualized for a pasture research scheme consists of (*a*) survey of the

vegetation with soil survey conducted concurrently, and (*b*) regional research stations based upon the main vegetation communities, with sub-stations to serve transitional zones and associations connected with exceptional soil types. At these stations the management of natural pasture would be investigated, and work carried out upon individual pasture plants and the management of artificially established pasture, where such development is appropriate to the region concerned.

ITEM 3 (*c*)

EFFECT OF DIFFERENT SYSTEMS OF PASTURE MANAGEMENT ON YIELD OF ARABLE CROPS.

Note by R. K. Kerkham

(A) Short Grass Areas.

Early work in Uganda on pasture problems consisted of a series of unrelated investigations, few of which included carefully controlled experiments. They included:—

(i) Identification and classification of natural grass species together with collection of data on their ecology.

(ii) Introduction of promising species from outside Uganda and movements of species within Uganda.

(iii) Preliminary grazing observations with the more promising species.

(iv) Observations on root structure and correlation with soil structure measurements carried out by the chemical section.

(v) Field scale observations of rotations which included the grazed resting ley as the main means of maintaining fertility. In some cases the grazed ley was compared with the ungrazed fallow under grass.

By about 1938 indications had been given that the grass fallow will maintain soil fertility, whereas green manures and organic manures will not. This had not been confirmed by a series of carefully controlled experiments, and could no doubt be shown to be untrue under certain special circumstances, but was undoubtedly sufficiently well established to form the basic premise for the Department to work upon.

At this stage (i.e. from 1938 onwards) a series of experiments was started to find out how the grazed ley compared with the ungrazed grass fallow for maintenance of fertility. In the first place, experiments were carried out at Ngetta and Serere Experiment Stations. These experiments have now been continued long enough to produce reasonably reliable results. The result has been that crop yields after the grazed ley are certainly no lower than after ungrazed grass. In all probability they are slightly higher.

In addition to this basic information a certain amount of experimental work has been carried out on the following subsidiary problems.

(*a*) Length of the ley and proportion of cropped land to ley. The optimum cropping ratio appears to be 3:3, 3:2 or 2:3 on most of our short grass soils. Cultivation for periods greater than three years is undesirable owing to loss of fertility and danger of erosion; leys of longer duration than three years tend to decrease in carrying capacity and have not been found to lead to any noticeable increase in crop yields.

(*b*) *Grass Species.*—In much of the country referred to Cynodon rapidly becomes the dominant grass species when the ley regenerates naturally after not more than three years' cropping. Natural regeneration has not been shown to be inferior to seeded grasses under these conditions. (This finding is almost certainly not true for elephant grass country.) Numerous species have been tried, of which the most promising so far is a local Teso strain of Rhodes grass, *Chloris gayana*.

(*c*) *Stocking Intensity.*—Some evidence has been obtained at Serere that stocking rates greater than one beast to the acre decrease fertility, and a rate of three-quarters of a beast might be preferable. In areas where the late rains are more reliable, such as Ngetta in Lango, one beast can be carried satisfactorily. Carrying capacities refer to figures obtained from fixed herd systems, i.e. the cattle are kept on the land all the year round. Cattle in most cases were growing bullocks, making gains of 160-180 lb. per year.

(*d*) *Rotational Grazing.*—Indications are that a three or four paddock system is the best, and definitely superior to continuous. A deferred continuous system, with each paddock rested from grazing for one wet season in the three years of the ley, is probably superior to a straight rotational system.

It must be emphasized that no experimental work has been carried out on our sandy soils; results mentioned refer to soils having a definite structure carrying such grasses as *Imperata cylindrica, Hyparrhenia rufa* and other perennial grasses.

(B) Elephant Grass Areas.

Nor is the true elephant grass country of Buganda included above, where rainfall is better distributed, soils more fertile, and human population denser. It is not naturally good cattle country, but prices of milk and meat are high, and owners have shown that they are prepared to spend time and money on the supplementary feeding and better management that is necessary if cattle are to thrive, provided they can see an economic return. Experimental work has only recently been started and the major problems in this area are concerned with:—

(*a*) Utilization of manure.

(*b*) Better use of this poor hillside grazing.

(*c*) Use of the grass produced on the grass fallow.

The first two problems are being studied at various stations, but will not concern the subject of this paper unless it can be shown that any permanent grazing areas would benefit from periodic cultivation.

Pasture work at Kawanda is largely concerned with (*c*). Under existing farming practice, these fallows are not grazed; on such fertile soils, situated near the main consuming centres of Uganda, crop production is the major consideration. The land produces more food from crops than from cattle, and the function of live stock is to make the best use it can of grass, but subordinate to the necessity of not interfering with maximum food production.

The main subjects under experiment are:—

(i) Cropping ratio. The 3:3 ratio is at present advised; while this is accepted in the short grass areas, there is doubt if it is economic in the elephant grass areas. Clearing is more expensive, crop yields drop less rapidly and couch is a consideration.

(ii) Search for grasses easier to clear than elephant grass, yet which produce a reasonable crumb structure. Recent work by the Chemical Section is promising.

(iii) Effects on fertility. While there is little doubt that grazing has little adverse effect on fertility, it is reputed to encourage couch, a serious weed on these soils. Grazing also makes the soils very compact and difficult to cultivate, and with land cultivation, heavy grazing is very probably uneconomic. This difficulty would disappear if mechanical cultivation came in, which is possible.

(iv) Methods of planting and utilizing elephant grass. Planting instead of the slower natural regeneration may hasten recovery of structure, but it is more expensive; various methods of reducing costs are being tried, and the couch problem again being studied, so far without success. Cutting and stall feeding of elephant grass is being compared with grazing. Greater production of grass per acre is very probable with stall feeding, but the effect on fertility is not yet known.

Note by D. W. Duthie

The highly leached sandy soils of the higher rainfall areas, notably the coastal strip of Kenya and Tanganyika, offer an important field of investigation in soil improvement. There is good reason to suppose that highly nutritive pastures could be established with the aid of phosphatic and nitrogenous fertilizers, and intensive dairy farming for the towns might give a good return for the expenditure. These pastures could then be used for annual crops in rotation, probably without the addition of fertilizers during the cropping period. Problems of leguminous crops would also form part of such an investigation, since it is possible that legumes could replace nitrogenous fertilizers after soil improvement has proceeded beyond the initial stages.

ITEM 3 (*d*)

Problems of Leguminous Crops

Note by B. A. Keen

In conditions of temperate agriculture there is an extensive body of scientific and practical knowledge on the culture of legumes, ranging from fundamental work on symbiosis and fertility inter-actions between the soil and the legume, to agronomical factors dealing with legumes in pure and mixed stands, and their use in green manuring.

In the agricultural development of the tropics and sub-tropics it was initially (and unavoidably) assumed that that knowledge could be applied without substantial modifications, but experience has shown that this is not so. Thus, in parts of the Middle East, a poor wheat yield is obtained after a legume crop—the reverse of Western experience. The effect has long been known to the peasant cultivators of Bulgaria, and it is also found

in Cyprus and Palestine; the reason is not at all clear. Again, the culture of legumes in pure stands, their place and function in grass leys and fodders, and in green manuring under East African conditions also require much further study.

In fundamental research there are problems of nodulation, and its relation to soil micro-biological, chemical and physical factors. On the agronomic side, useful work has already been done by agricultural and "pasture research" officers, much of which was brought together and discussed at the 1940 Pasture Research Conference.

However, no one would suggest that we have, as yet, satisfactory proof (or disproof) of various statements in text-books of tropical agriculture on problems of practical importance, such as the function of legumes on the nitrogen status of the soil, and the extent to which a leguminous green manure affects the yield of annual and permanent crops.

There is a clear case for an early attack on the general problem of leguminous crops, in all the three divisions of research: fundamental, technological and agronomical.

Summary of Discussion

The four sub-sections of Item 3 were considered together.

Mr. Blunt recalled the East African Pasture Research Conference which was held in 1940, and at which an inter-territorial pasture research scheme was planned. Owing to the war this scheme could not be put into effect, and because of this the Kenya Government had decided to make an independent start. They had already carried out a considerable amount of work, but he thought that pasture research should be co-ordinated on an inter-territorial basis as soon as possible and that every effort should be made to carry out the essential preliminary soil and ecological surveys, even before the pasture research scheme as a whole came into being. Mr. Edwards agreed with the latter suggestion, but he thought the term "pasture research" too narrow for the type of work which should be carried out. He suggested that the whole research plan of East African Agricultural and Forestry Research Organization should be built on an ecological foundation, since the ecological approach is of great importance in all aspects of development. In his opinion the notes submitted to the Conference did not show sufficient appreciation of the fact that East Africa could be divided into ecological regions. Mr. van Rensburg also stressed the importance of ecological surveys, pointing out that pasture research should be treated as an integral part of land utilization studies. In the latter respect, the management of grassland may have an effect on adjacent lands; for instance the clearing of bush for grazing may affect the water supplies over a large area.

Mr. Kerkham said that the Uganda Husbandry Committee consider that grassland research should not be taken as a problem in itself, but as only one aspect of agricultural improvement. They had found that there is an increase in fertility when grass leys are grazed, as compared with ungrazed leys, and he emphasized this link between crop and animal husbandry. He stressed the importance of the application side of research which is now being carried out by territorial departments, and pointed out that the only real test of a farming system is the crops which are produced on that land, not the yield per acre in any particular year but the effect of the crops on the land and on the farmer, over a number of years.

Dr. Duthie suggested that grass might be used to raise the fertility of the leached soils of the higher rainfall areas. By applying fertilizers to grass ley the mineral deficiencies of these poor soils could be corrected, the organic content of the topsoil would be raised, and leaching would be greatly reduced. Short-term cropping, alternating with fertilized grass fallow, might be the most efficient method of using these soils, but intensive farming would be necessary, and proximity to markets and relatively cheap fertilizers would probably be key factors in the economy of such a system.

Mr. Blunt stressed that the interaction between the animal and the pasture is fundamental to agricultural improvement, and he suggested that alternate husbandry, under a rotational system of mixed farming, would provide the best means of raising the standard of agriculture. For this, stock improvement and better methods of animal husbandry would be required. Mr. Beaumont agreed to the need for better stock, but he pointed out that control of disease is essential before raising the quality by breeding, since high-grade stock are usually very susceptible to disease. With regard to animal husbandry, he said that, since Dr. White, Director-Designate of the East African Veterinary Research Organization, was coming from the Rowett Research Institute, it seemed highly

probable that animal nutrition would be given an important place in the research programme of that organization.

The subjects considered under Item 3 were referred to a Study Group, with Mr. Kerkham as Convener, and their report is given below.

REPORT OF THE STUDY GROUP

The basic factors which affect farming systems are:—

(*a*) Ecological, e.g. vegetation, soils and climate.

(*b*) Economic, e.g. distance from markets.

(*c*) Sociological, e.g. tribal customs.

The main ecological types are as follows:—

(*a*) *Semi-desert vegetation;* divided into true desert, desert scrub consisting of dwarf bush and tree vegetation with annual grasses and herbs, desert grass bush consisting of dry bush with trees and perennial short grasses. In these areas crop production is possible only near permanent trees which are rare. The main economic products are cattle, goats, sheep and camels.

(*b*) *Scattered tree grassland;* this is the Acacia-Themeda association, where some cultivation is possible, but animal production predominates, especially beef cattle.

(*c*) *Brachystegia-Isoberlinia woodland;* with tall perennial grass and light sandy soil predominant: this type is suitable for mixed farming.

(*d*) *Deciduous thicket,* including *Commiphora,* with red sandy loam: it is suitable for mixed farming and for groundnuts.

(*e*) *Scattered tree grassland;* consisting of low tree growth and high grass, *Combretum-Hyparrhenia*: this is suitable for mixed farming systems, including beef and butterfat production.

(*f*) *Coastal high grass bush;* this is suitable for crop and animal production, but animals are limited by tsetse. Perennial crops are important and the type is potentially a milk producing area owing to proximity to markets.

(*g*) *Highland grassland and highland forest;* temperature is relatively low; rainfall more than 40 inches, and Kikuyu grass is common. It is basically suitable for alternate husbandry.

(*h*) *Tropical rain forest,* including elephant grass zones and Cymbopogon on poor soil; human population is relatively dense and cropped production takes precedence over animals. Milk can be produced and cattle fattened.

The major problems applying to all ecological types listed above can be divided into:—

(*a*) *Problems of mixed farming*:—

(i) the study of indigenous vegetation and the selection of promising pasture plants.

(ii) digestibility work on forage crops, crop residues and natural grassland.

(iii) mineral deficiencies, including analyses of pasture plants and soil.

(iv) technique of farm rotation trials and pasture management experiments.

(v) seed research and testing of viability, and dormancy.

(vi) plant introduction.

(*b*) *Problems not peculiar to mixed farming*:—

(i) tsetse work.

(ii) afforestation.

The main problems applying to semi-desert vegetation are:—

(*a*) Water conservation and distribution.

(*b*) Control of tribal movement.

(*c*) Control of burning.

(*d*) Conservation of fodder for the dry season.

(*e*) Rotational and deferred systems of grazing on extensive lines.

(*f*) Clearing of thorn-scrub.

The main problems applying to other vegetational types, that is the types suitable for mixed farming, can be divided into:—

(*a*) Farm rotations.

(*b*) Cropping ratio expressed as yield of crops and meat.

(*c*) Effect of grazing the resting leys.

(*d*) Utilization of manure, especially its use as F.Y.M. or dropped manure.

(*e*) Management of the ley, e.g. rotational, deferred grazing, cover during the resting period, when to start and stop grazing.

(*f*) Management of permanent grazing land, e.g. burning rotational grazing.

(*g*) Supplementary feeding of cattle, including the use of crop wastes.

(*h*) Conservation of fodder.

In view of the above findings, it is recommended that major stations should be based on ecological regions in the first place, though sub-stations will be required to allow for economic and sociological factors, and for transitional ecological types and minor types. The stations should be considered as farming systems stations, not restricted only to pasture research.

These conclusions do not conflict with those of the 1940 Pasture Research Conference. In principle they conform, although the emphasis in some cases is changed.

ITEM 4

Plant Food Status with Special Reference to the Action of Organic and Inorganic Fertilizers.

Note by D. W. Duthie

It is usual to judge the fertility of a soil by its content of "available" plant foods, but with tropical soils under native methods of cultivation it is of some importance that the amount of "reserve" nutrients should be known as well. While the analytical methods for these are arbitrary, they do allow comparison between soils, the field behaviour of which is known. Large areas of East Africa carry soils with low contents of "available" nutrients (P, Ca, Mg, Na, K), but our knowledge of the "reserve" plant foods is too scanty for generalization. Soil deterioration and soil exhaustion, vague terms which are nevertheless useful in agricultural practice, may depend on the relationships between reserve and available nutrients, although physical factors appear to be of primary importance on some soil types.

Information on the fertility status of East African soils has not been collected at Amani, since the work there during the period 1928-42 was mainly concerned with the broad classification of soil types. Those samples which have been analysed for fertility status were usually taken for a specific purpose, e.g. salinity on sisal and sugar estates, and not for a general study of the soils of native areas. This applies particularly to Tanganyika, but there may be much more information of the kind required in the Kenya and Uganda departmental files.

We assume that N.K. Mg. and Na are straightforward in action so that field experiments and chemical analyses are sufficient to give definite information as to whether the soil requires these. Lime, formerly looked on as a soil ameliorant rather than as a fertilizer, is beginning to assume more importance as a supplier of calcium on soils which are deficient in this element. Thus lime may have two distinct functions—the physical improvement of heavy soils by producing calcium-clays of good tilth, and the correction of calcium deficiency by supplying calcium direct to the plant.

The action of phosphate, whether naturally present in the soil or added as fertilizer, is not well known even in temperate soils, and in some tropical soils there is a further complication in the presence of comparatively large amounts of iron and aluminium compounds which are capable of immobilizing added phosphate. Soil acidity also plays a large part in the action of added phosphate, and it has been found that crops requiring acid soils may make good use of rock phosphate. But this work has been done mainly in temperate climates and further study is required under tropical conditions. Organic matter is also important in preventing phosphate fixation in the soil, as the humates combine with iron and aluminium and prevent them from immobilizing phosphate. Potash was found to interact with phosphate in New South Wales, where it was found that lack of response to superphosphate was an indication of potash deficiency.

Work on the plant food status of East African soils falls into two main lines.

(*a*) Soil and plant analyses complementary to field fertilizer trials in order to explain, to some extent at least, what happens to the added chemicals.

(*b*) A special study of the fertility status of East African soils with primary emphasis on forms and amount of phosphate occurring in the soil and the fate of added phosphate of different kinds. Phosphate fixation is included in this section.

The first section involves a very large volume of analytical work, and steps have already been taken to improve the analytical facilities at Amani. Dr. Black, Soil Chemist of the Cinchona Organization, has left for the United Kingdom to study spectrographic methods of analysis, and it is hoped to speed up very greatly the estimation of the major elements (Ca, Mg, Na, K) and some work may also be done on the trace elements. The

Colonial Office is now advertising for two women graduates in science as scientific assistants for routine chemical analysis.

A start is now being made on the study of the phosphate status of those soil types which are likely to be used for fertilizer trials, and Dr. Birch, Organic Chemist in the Cinchona Organization, has made a preliminary survey of the literature on the subject. His notes on the subject, outlined below, will show the practical importance of this special study.

There is a comparatively large number of forms of phosphates in soils from which a plant may obtain part of its phosphorus to a varying degree throughout a growing season. The modern approach in soil phosphate studies is therefore to determine the amount of each form in which phosphate is present, and a technique has been worked out in America for the resolution of soil phosphate into the three fractions:—

Water soluble phosphate.

Adsorbed and replaceable phosphate.

Acid-soluble phosphate.

This method of approach has obvious advantages over acid extraction methods, as illustrated by Truog's, which are neither specific as to the kind of phosphate dissolved nor quantitative as to the amounts of the dissolved phosphate which can be extracted. These methods are, moreover, based on the fallacious assumption that the acid extractants simulate the dissolving action of a plant root.

In America some interesting relationships have already been found between the adsorbed and acid-soluble phosphate status of a soil on the one hand and its productivity and crop response to added superphosphate and rock phosphate on the other. Two examples are given below that illustrate the advantages of the fractionation method in soil phosphate studies.

(*a*) One soil gave the high figure of 430 p.p.m. "available" phosphate by Truog's method and therefore was not expected to respond to phosphate; it did, however, respond markedly to dressings of superphosphate. By the new analytical method the content of adsorbed phosphate was found to be low, and this explained the response to phosphate.

(*b*) Another soil gave the low figure of 18 p.p.m. available phosphate (Truog's method), indicating phosphate deficiency, but according to the new method the content of adsorbed phosphate was relatively high and no response could be expected from dressings of phosphate. Field trials confirmed the effect of added phosphate was small.

The object of the investigations started here is, briefly, to correlate the various forms of soil phosphate with the growth of a given crop and, in conjunction with the fertilizer trials being laid down, to establish a field calibration. The information that will accrue will be of practical value. The response of a soil to different phosphate fertilizers will be correlated with its status of adsorbed and acid soluble phosphates, and considerable economies may be effected in the use of phosphatic fertilizers if it is known on which soils rock phosphate is likely to have an effect approaching that of superphosphate. On the other hand, analysis of the phosphate fractions should also indicate those soils on which rock phosphate would not be expected to show a response.

Phosphate fixation studies, using the same fractionation technique, with various phosphatic fertilizers and soils, will form an integral part of the research scheme. The types of clay minerals, organic matter, texture and pH of the soil all have an important bearing on the subject.

Summary of Discussion

Dr. Duthie suggested that the striking effects of grass rotation in Uganda might be due, in part, to the grass ley rendering reserve minerals available to crop plants, and he pointed out that a soil which is low in inorganic plant foods cannot be made fertile by grass alone. Of the major chemical components of the soil, phosphate is the most difficult to understand, since its action is affected by iron and aluminium compounds, by acidity, by organic matter, and possibly also by the relative proportions of other major elements. Recent work in the United States had raised fresh hopes of obtaining correlation between laboratory tests and crop response, but these results could not be applied to tropical soils without further investigation. Dr. Bunting put forward the suggestion that certain grasses may have the power of releasing phosphate which had been fixed by the soil and would not normally be available to crop plants, and he also pointed out that organic manures play an important part in phosphate studies.

ITEM 5

Mechanized Farming and the Need for Investigation

Note by R. W. R. Miller

It may be said without question that the economic development of East Africa depends on the proper use of mechanical cultivation. In fact, what development has already been accomplished would never have been recorded but for the surplus grain production produced by the plough by European farmers and by the Africans of the Nyanza Province of Kenya.

Hitherto, however, we have hardly reached the fringe of the problem. The orderly development of the African demands that tribal life should not be disrupted more than is essential for his progress and there is general agreement amongst the Administrations that from ten to twenty per cent of the man power is the maximum which should be away from their homes at any one time. This gives us between half a million and a million workers. The present necessity, which is East Africa's golden opportunity, to produce crops which yield, or at any rate save dollars, demands that no stone should be left unturned whereby wasted labour can be diverted to worth-while production.

The alternative is to import food (whenever it may become again in free supply) and to use the consequent saving of labour in the production of sisal, tobacco, pyrethrum, papain, coffee—not to mention minerals and timber, the building of railways, etc.

It is understood that already at least one of the East African Governments is considering the setting up of a Central Labour Utilization Board, whose responsibility will not only be the allocation of labour to different industries, but also its economic utilization.

One of the most important duties of the territorial governments will be the investigation of the best method of economizing in labour by the use of chemical, physical and mechanical means. A certain part of these investigations may well come within the orbit of the East African Agricultural Research Organization, although many of these the Conference may consider not to be problems of fundamental research.

Outstanding problems will include:—

(*a*) Mechanical preparations of the land to increase acreages, but mainly to ensure optimum time of planting.

(*b*) Mechanical planting.

(*c*) Mechanical weeding.

(*d*) Chemical control of weeds.

(*e*) Control of weeds by flame throwers, etc.

(*f*) Mechanical after-cultivation.

(*g*) Mechanical harvesting.

(*h*) Improvement of processing.

The constant bugbear of famine and the needless tying up of African labour in uneconomic production of staple foods is already receiving attention, and the Government of Tanganyika is investigating the inauguration of schemes for mechanical production of food crops in African areas.

Questions such as the best use of mechanical implements in co-operative or collective farming by Africans may be considered by the Conference, at any rate in their inception, to be problems which should be undertaken by a central organization.

The fundamental work on chemical weed control should certainly be a function of the Research Institute, together with work on the use of flame throwers plus, in certain instances, the design and adaptation of agricultural implements which, in many cases, appear to have been designed without consideration of such problems as:—

(*a*) Working on contours.

(*b*) Weeding of permanent crops which are often surface feeders.

(*c*) The correct type of light cultivator for use on surfaces much rougher than are customary on European and American farms.

Note by D. W. Duthie.

Mechanical methods of cultivation might make it possible to use to good purpose the clay soils of depressions and valley bottoms. These soils are usually well supplied with plant nutrients, but they are intractable under native methods of cultivation and are periodically flooded. Small-scale drainage schemes might be sufficient to control flood-water in many areas, and heavy-duty ploughs could deal effectively with the hardest clays. Flood-fallowing might also be tried, but in most places it would be difficult to keep the soil under water for long periods.

Development along these lines in native areas would have to be communal, but a successful method of using these valley-bottom soils would probably lead to a considerable increase in food production in some of the over-populated areas.

Summary of Discussion

There was general agreement that the investigation of mechanized farming should be carried out on an inter-territorial basis under the E.A.A. and F.R.O. Advice could be sought from the National Institute of Agricultural Engineering in England, particularly in the design of implements suitable for East African conditions or for special purposes.

Mr. Swainson and Mr. Sunman both drew attention to the danger of accelerating soil erosion and deterioration by putting tractor-drawn farming implements into the hand of Africans, thereby enabling them to cultivate larger areas per family. They thought that mechanization of native farming would have to be accompanied by strict control of land use. It was also suggested that there might be a tendency to look on mechanization as a panacea, whereas it is really only a branch of agricultural improvement. In itself it might be more dangerous than beneficial.

ITEM 6

East African Agricultural and Forestry Journal

Note by J. C. Rammell

During 1946 it was suggested that the time had come when it would be advisable to launch experimentally a journal devoted to Forestry. The type of publication contemplated was one in which members of the Departments primarily could contribute long or short articles, observations and queries and thus the journal would become a medium through which ideas and thought on the technical aspects of forestry in East Africa could be made known and discussed. It would as an entity stand or fall by the interest and contributions of officers of all races in the Departments.

At the Conservators' Conference in January, 1947, it was agreed that some such publication was desirable, but it was also pointed out that a multiplicity of journals was in many ways undesirable. The suggestion was made that wider publicity and greater benefit would be obtained if the *East African Agricultural Journal* was extended to include forestry and its title altered to indicate this.

There is much in favour of this suggestion so long as the Forestry Section is designed to publish short notes and queries on subjects of general technical interest from all officers and others and not confined to the longer and more formal article.

Summary of Discussion

In a short discussion on Mr. Rammell's note it was agreed that the time is not yet ripe for the publication of separate East African journals of forestry and veterinary science. Since alterations in the title of a technical journal are always undesirable on account of the danger of confusing references to articles in it, it was also agreed that the title should remain as at present, and the Drafting Committee was asked to prepare a resolution on the subject.

At the final session of the Conference the following resolution was adopted:—

> "The Conference resolved that it would be undesirable at the present stage to inaugurate separate journals for animal industry or forestry. Accordingly, the existing title should be maintained and the Journal should continue to include papers on these subjects, and might be enlarged by the addition of more short articles of local topical interest."

ITEM 7

A "Flora" for East Africa

Note by P. J. Greenway

If ecological, soil and land utilization surveys on an inter-territorial basis and pasture research in its widest sense are to be properly carried out, it is essential that the very widely scattered information on East African plants that has been published in numerous botanical periodicals should be assembled in a regional flora, where it would be easily available to those workers and others in East Africa, as well as to the systematists who will be engaged in naming the plants collected during such work.

The production of such a regional flora entails the study of the type specimens, the majority of which are housed in British, French, Belgian, German, Danish and Swedish botanical institutions in Europe. The rich, but not always correctly named, collections from East Africa in British institutions will have to be compared with these types.

For quick results such a task is beyond the scope of a single individual and the services of specialists not only at home but the Continent and America should be enlisted. If this assistance is forthcoming an editorial board should be set up at a botanical institution like that of the Royal Botanic Gardens, Kew. The

duties of the board would be to assign the work to those willing to help write the flora, and make arrangements for the publication of the results. Publication should not, however, be held up until a large amount of manuscript was ready for publishing in one volume, but as a genus was completed it should be published in a loose leaf form so that it would be immediately available to the workers in East Africa as well as to those interested in other parts of the world, and to which other material could be added as it was forthcoming.

In this manner the more important families such as the Gramineæ, Leguminosæ and Meliaceæ, etc., could be dealt with first and the less important groups could follow later. Keys to the families could be left till the last, but those for the genera would have to be published when a family was completed.

To be of use both to the non-technical as well as the technical man the flora should be written in non-botanical language. There should be a line drawing illustrating the most common member of each genus; the type specimen should always be cited if possible; when not numerous, collectors' specimens should be quoted (more especially of those known to have collected material in duplicate or triplicate); if there are numerous collections of a species then citations of one or two specimens from each geo-political area should be given. It is also essential that the geographical range as well as the habitat of a species should be indicated.

If a loose leaf system of publication is used, the regional flora should never become out of date; fresh knowledge as it became available could be added at every decade to a genus or family as well as to bring the keys up to date.

As soon as a regional flora is published, then more detailed studies could be undertaken in East Africa not only in systematic, but in ecological and economic botany as well. The first essential is to get the identity of a species correctly established, but this can only be done by comparing the large mass of material available with the type specimens of the different species, the bulk of which are to be found in European institutions, and to assembling the information in one publication.

Note by P. R. O. Bally
(Botanist at Coryndon Museum)

(Mr. Bally agrees with the above statement by Mr. Greenway, but has added comments, of which the following is an extract.)

There is a further significance in a thorough knowledge of the East African flora, comparable to a geological or mineralogical survey: an assessment of the inherent possibilities of the indigenous plants, not only terms of cubic feet of timber, etc., but of other direct economic possibilities.

In East Africa there are to this day many hundreds of plants unknown and unrecorded by ourselves, and many thousands which have not been investigated as to their specific properties. Many of them may have important economical or medicinal properties, but chemical research in this domain is as yet quite negligible. Granted, out of a hundred investigated plants there may be barely one with economic importance, but the possibility is there, nevertheless. What do we know of indigenous essential oil plants, what of our heart poisons, insecticides, what—to mention a new line of research—of the hormones to be found in African plants? To gain this information with the help of the fast disappearing native lore would mean an invaluable short-cut for research.

Not only are we destroying the traditional knowledge of native tribes on plant uses, but our modern large-scale agriculture which subjugates immense areas under uniform crops tends to exterminate individual plant species, and the host of cosmopolitan weeds which follow relentlessly in our wake adds to this damage. Many indigenous plants, especially the rarer ones, are delicately adapted to special conditions; only a slight disturbance may bring about their disappearance.

Therefore, an all-out effort should be made *without delay* to undertake a botanical survey of East Africa, with all the means available, of man power and of finances. Such a survey should consist of concerted fieldwork by professional collectors, agricultural and forest officers and by suitable members of the European population in the Colony, the results of such fieldwork compiled and pre-digested in a suitable Institution in East Africa.

The second phase would be research work at home. It would consist of:—

(*a*) Determination of all collected specimens in Kew, the British Museum, Oxford or other Institutions dealing with plant taxonomy.

(*b*) Investigation of all plants with inherent economic, medicinal, or other uses by the Imperial Institute, Universities or other appropriate Institutions, even private or commercial concerns.

The Kew Herbarium is the obvious place in which the taxonomic work should be centred. Unfortunately at present Kew is hardly equal to the task, being greatly understaffed and lacking in funds. When a short while ago a member of the Kew staff was asked to investigate the possibility of producing a "Flora of East Tropical Africa" (Kew are fully aware of the urgent need for such a publication) he estimated, after carefully assessing the work involved, that under present conditions it would take the *better part of* 20 *years* to write up only the material which is now represented in Kew and other botanical Institutions in England and on the Continent. The fact that a great deal of collecting has yet to be done in order to make such a publication anything near complete was not considered in this estimate.

In Kew Herbarium the accumulated arrears of African plants to be identified amount to 30,000 specimens, the accumulation of about six years, and a staff only a fraction of its pre-war strength to deal with it. This position is most discouraging to even the most enthusiastic collector, field or scientific worker who cannot hope to get his material identified within anything approaching a reasonable time and who must thus see the results of his efforts held up indefinitely.

The war has greatly increased the importance of the Kew Herbarium, especially to East Africa, for all the very considerable collections of East African plants in Germany, including a great number of type specimens, have been destroyed.

Note by E. B. Worthington

Correspondence took place during 1930-1933 between the Secretary of State and the Governors of the East African and Central African territories on the subject of an East African Flora, but the project had to be abandoned owing to the difficult financial conditions which then obtained.

The Uganda Government has recently raised the matter again officially in a letter of 31-5-47 to the Governors' Conference (copies to Governors of Kenya, Tanganyika, Zanzibar, N. Rhodesia and Nyasaland). In this letter Uganda presses for the preparation of a flora without more delay.

The question of preparing a flora relates closely to paragraphs 52 and 53 of Paper No. 2 (East African Agricultural and Forestry Research Organization) referring to relations between the organization and the Coryndon Memorial Museum and proposed Colonial Biological Survey. If the proposals for a Colonial Biological Survey are approved, facilities for preparing an East African flora on sound lines would be much improved.

Summary of Discussion

Mr. Greenway recalled that various speakers at this meeting had stressed the importance of ecological surveys, and if these were to be carried out efficiently it was essential that a flora should be published to enable workers to identify the species of the ecological types. Such a flora can only be prepared in England, with easy access to the type specimens in the main herbaria. Shortage of staff at the Royal Botanic Gardens, Kew, had prevented the compilation of an East African flora, and he urged that an attempt should be made by the Governments concerned to make it possible for Kew to undertake this work. He went on to say that work is now being carried out at Kew towards the completion of the Gramineæ of the Flora of Tropical Africa, and he suggested that advantage should be taken of this fact by starting with this family in the Flora of East Africa. Dr. Storey said that Kew was anxious to proceed with the publication of an East African flora, but it was unlikely that the necessary staff would be available for some considerable time.

After further discussion it was agreed that, as this is a matter of primary importance in the ecological work which is now being done in East Africa, and will be even more important when the work is extended under the new research organization, that the Conference should put forward its views in the form of a resolution. Accordingly, the following resolution was adopted at the final session:—

> "The Conference took note of representations made by the Government of Uganda, supported by the other East African territories, and recognized the need for a flora in connexion with development of the plant and animal industries in the region.
>
> The Conference resolved that the Colonial Office be requested to examine the practical and financial means by which a Flora of East Africa could be prepared and published, and suggested that the Director of the Royal Botanic Gardens at Kew be invited to provide headquarters, in collaboration with other botanical institutes in Europe, America and Africa.
>
> The Conference further suggested that the families of primary economic importance, especially the *Gramineæ*, should take priority in this work."

THE CONTROL OF CONTAGIOUS ABORTION BY CALFHOOD VACCINATION

By S. E. Piercy, Veterinary Research Officer, Veterinary Research Laboratory, Kabete, Kenya

(*Received for publication on 26th June, 1947*)

Introduction

Within recent years it has become evident that bovine contagious obortion is widespread throughout Kenya Colony. In the past such striking and deadly diseases as rinderpest and pleuro-pneumonia have monopolized the attention of farmer and scientist, and it is only since these major epidemics have been brought under control that the presence and significance of less spectacular diseases such as contagious abortion have emerged from comparative obscurity. The rapid expansion of the dairy industry, the adoption of improved methods of animal husbandry, and the importation of valuable stock have all served to focus attention on this disease and its attendant losses through abortion and sterility.

The use of vaccines in an attempt to control contagious abortion has been practised somewhat sporadically in Kenya for many years, but coincident with increased interest in this disease, dairy farmers have shown a marked desire to immunize their herds on a larger scale and in a more regular manner. Reports from Great Britain and America of the successful control of contagious abortion by the inoculation of calves with a vaccine known as Strain 19 have aroused considerable interest resulting in many queries from farmers anxious to know more details of this method and whether its use in Kenya is advocated by the Veterinary Department. The purpose of this article, therefore, is to outline the history of calfhood vaccination, to discuss its value and application, and to examine the results of certain experiments designed to compare the antibody response of calves inoculated with Strain 19 vaccine and the routine Kabete vaccine.

History of Calfhood Vaccination

Attempts, to produce effective but safe vaccines for the prevention and control of contagious abortion were commenced in various countries many years ago. It was soon found that live cultures containing virulent organisms effectively reduced the incidence of the disease, but the risk of establishing a persistent infection in the tissues of inoculated animals, particularly in the udder, meant that there was always a danger of introducing infection into clean herds with the added risk of infecting milk consumers. Dead vaccines, on the other hand, whilst perfectly safe to use, did not produce an effective immunity. Scientists then directed their energies towards the isolation of a strain of *Brucella abortus* sufficiently attenuated to obviate the dangers associated with the use of fully virulent organisms, yet virulent enough to stimulate a serviceable immunity in inoculated animals.

In 1930, Buck, an American veterinarian, published the results of his investigations into the possibility of inoculating young calves with a vaccine prepared from an attenuated type of *Brucella abortus* which he named Strain 19. His experiments indicated that an immunity was engendered during calfhood which persisted over the first two pregnancies, whilst certain objectionable features, such as abortions, which sometimes accompany the vaccination of adult animals were overcome. Cotton [3] and Cotton, Buck and Smith [4], [5], [6], carried out further trials with strains of *Brucella* of varying virulency and found that vaccination at 4–6 months old conferred a distinct immunity for the first and possibly the second gestations, and that Strain 19, of low virulency, was just as effective as another Strain (618) of high virulency.

As a result of these findings many and varied experiments were carried out in the United States during the next few years. Tompkins [15] has summarized these and states that although some abortions occurred in animals immunized as calves, only a small percentage was due to *Brucella abortus*, for it must be borne in mind that numerous other factors may cause or predispose cattle to abortion. An interesting and important observation was that live organisms were not transmitted in the milk of heifers inoculated with Strain 19 in calfhood.

Veterinarians in Britain observed these results with lively interest and, meanwhile, McEwen [9–14] had been developing the use of another strain of *Brucella* which he called "45/20". This differs from Strain 19 in several important respects, particularly in its failure to cause the appearance of demonstrable antibodies in the sera of inoculated animals. This is a useful advantage over Strain 19 since its use does not interfere with the agglutination test, a laboratory test designed to reveal natural

infection by the demonstration of antibodies in the sera of suspected animals. The Ministry of Agriculture finally gave official approval to the use of these two vaccines on a commercial scale when they became known as Vaccine No. 1 (Strain 19) and Vaccine No. 2 (Strain 45/20). Considerable controversy soon arose, however, as to the relative merits of these two vaccines, and the Agricultural Research Council initiated a series of trials designed to establish which of the two vaccines was superior in immunizing properties and in safety. The results of these investigations have been published by Edwards, De Ropp and McLeod [7], and Edwards, McDiarmid, De Ropp and McLeod [8], and show clearly that Strain 19 is a better immunizing agent than Strain 45/20. Moreover, although Strain 45/20 has the advantage of not producing demonstrable antibodies (agglutinins) in non-pregnant cattle, the possibility of the organisms increasing in virulency to a dangerous extent in the inoculated animal cannot be excluded, whereas this does not occur with Strain 19. It seems likely, therefore, that the balance of opinion will swing sharply in favour of Strain 19 and that this vaccine will be as widely used in Great Britain, as it is in America.

There has always been a certain reluctance on the part of farmers to resort to the use of living vaccines in the control of contagious abortion because of the fear that infection might be introduced into an almost, or entirely, clean herd, and it is true that control measures other than vaccination are available under ideal conditions. In Great Britain, for example, where farming is carried out on an intensive basis and on comparatively small acreages of land, and where extensive paddocking and fencing are the rule rather than the exception, it is possible to control the disease in herds where infection is not widespread by the prompt eradication of infected animals before the disease has a chance to spread. In other cases it may be possible to divide the herd into two entirely separate parts, clean and infected. On the great majority of farms in Kenya, however, this is not possible. Semi-ranching conditions of management, the necessity for leaving so much in the hands of comparatively unskilled and uninformed African labourers, and the lack of sufficient paddocks and fencing with the consequent danger of accidental or illicit trespass, all combine to make the establishment on the same farm of an infected herd in isolation from a clean one an impossible task. It is clear therefore that some method of vaccination is the only practical method of control, and calfhood vaccination is the method of choice.

Principles of Calfhood Vaccination

The principle underlying calfhood vaccination is to inoculate all heifer calves when they reach the age of 5–12 months, with a standardized, living, attenuated strain of *Brucella abortus*, such as Strain 19 or the Kabete strain. By inoculating animals early in life the danger of causing abortions is avoided although the vaccine used is a live one. One inoculation only is required. In herds which are known to be clean and where vaccination is carried out merely as a precaution against the possible introduction of the disease, it is probably worth while to inoculate female stock of all ages at the outset. Thereafter, no other measures should be necessary other than the periodical inoculation of young heifer calves. Where infection is already present, calfhood vaccination should be combined with the elimination or segregation of reactors to the agglutination test, and the vaccination of all other adult female stock. In the case of dry cows and heifers, an interval of some six weeks should be allowed to elapse between inoculation and service, so as to avoid the risk of causing abortions, whilst animals which have just calved should not be inoculated until all signs of discharge have disappeared, and, as before, the bull should be withheld for about six weeks. By adopting these measures the spread of infection is largely prevented. In the course of time the infected animals are eliminated by culling or death, and provided the inoculation of young calves is regularly performed, an immune herd is gradually built up. Infected animals acquire a natural immunity, although they may become carriers, and need not be inoculated.

The significance of the carrier animal must be thoroughly understood. As a general rule, infected animals abort once only, but a percentage become carriers of the disease constituting a grave danger to the remainder of the herd. Such animals may carry their calves to full-term and calve perfectly normally, but in actual fact, the after-births and discharges contain live *Brucella abortus* organisms. In this way the disease is maintained and spread. When any doubt exists, therefore, as to whether an animal is a carrier, a sample of blood should be taken some two weeks before the expected date of calving and sent to the laboratory for the agglutination test. Should

the result of the test show the animal to be a carrier special precautions may then be taken, when calving takes place, to isolate the animal and deal effectively with the after-birth and accompanying discharges.

It is not claimed that the adoption of calfhood vaccination will eliminate the disease or entirely prevent its introduction, but there is no doubt that this method provides a means of keeping contagious abortion within reasonable bounds. An interesting investigation by Birch, Gilman and Stone [1], carried out over a period of eight years, indicated that the vaccination of calves with Strain 19 failed to prevent abortions in many cases, but that these were usually delayed until the third or fourth pregnancies, compared with the first and second pregnancies in uninoculated controls. This delay assists in establishing clean herds, whilst the presence of resistant animals reduces the likelihood of natural infection establishing itself in highly virulent form.

Experimental

In Kenya, the Veterinary Department has been issuing a live, attenuated, abortion vaccine for over fifteen years. Until comparatively recently, however, this vaccine has been used somewhat sporadically, and in adult animals only. When publications from America made it clear that calfhood vaccination with Strain 19 was producing a considerable measure of success, it was realized that the Kabete strain might more usefully be used in a similar manner. Accordingly, calfhood vaccination with Kabete vaccine was tried out on a number of farms where contagious abortion had existed for some years. The results were sufficiently encouraging to warrant further investigations. It was also considered wise to compare the bacteriological characteristics of Strain 19 and the Kabete strain and the antibody response of calves inoculated with the two vaccines.

A detailed account of the bacteriological characteristics of the two strains would be out of place in an article of this nature. It is sufficient to say that there is a marked similarity as regards size, shape, grown requirements, survival on artificial media and reactions with immune sera. Of more immediate interest to the stockowner is a study of the production of antibodies in inoculated calves. A preliminary trial was carried out with four grade heifer calves, all being 6–7 months old. Two of them (4974 and 5170) were given 5 c.c. standard Kabete vaccine subcutaneously, and two (4927 and 4972) 5 c.c. Strain 19 vaccine, made up in exactly the same way and in the same strength as the Kabete vaccine. Before vaccination blood samples were collected and shown to be negative to the agglutination test. No clinical evidence of any reaction was observed following inoculation, but four days later both calves which received the Kabete vaccine showed the presence of antibodies to a titre of 1 in 20 (4974) and 1 in 40 (5170), (Table I). The two calves inoculated with Strain 19 showed no definite antibody reaction until the sixth day. Thereafter, both groups of calves showed a steady increase in antibody production until about the 13th day and it is interesting to observe that the sera of the calves receiving Kabete vaccine at this time were positive to the agglutination test at a dilution of 1 in 1,000, whereas the sera of the Strain 19 calves were negative at dilutions greater than 1 in 250. (The highest dilution at which a positive reaction is recorded is known as the titre of the serum under test.) Three weeks after inoculation a decline in antibody titre was observed in all cases, continuing until all eventually became negative.

A point of interest revealed by Table I is that whilst the Kabete vaccine calves showed a much greater antibody response as measured by the agglutination test, their sera took over three months to become negative, whereas negative returns were obtained from the Strain 19 calves in less than two months. This is a point which, if confirmed by more extensive trials, is of practical importance since the sooner demonstrable antibodies are no longer present in an animal's blood, the sooner it becomes possible to use the agglutination test again for the presence or absence of natural infection.

At about this time, detailed information was received as to the method of preparation of Strain 19 vaccine used at the Ministry of Agriculture's veterinary laboratories at Weybridge in England. It was noted that the Ministry's vaccine was twice as strong, in billions of live organisms per cubit centimetre of vaccine, than the Strain 19 vaccine used in the experiment just described. Accordingly, a further batch of this vaccine was prepared and standardized to the same strength as that advocated by the Ministry. On 31st December, 1943, three 6-month old, grade, heifer calves were given 5 c.c. of the stronger Strain 19 vaccine subcutaneously. The results of the subsequent agglutination tests are recorded in Table II.

TABLE I.

EXPERIMENT 1.

THE ANTIBODY RESPONSE OF CALVES TO SUBCUTANEOUS INOCULATION WITH 5 c.c. KABETE AND 5 c.c. STRAIN 19 VACCINES.

Calf No.	Interval after Inoculation.	Serum Dilutions.									
		20	40	80	125	250	500	1,000	2,000	4,000	8,000
5,170 Kabete Vaccine	1 day	—	—	—	—	—	—	—	—	—	—
	2 days	—	—	—	—	—	—	—	—	—	—
	3 ,,	—	—	—	—	—	—	—	—	—	—
	4 ,,	++	++	T	—	—	—	—	—	—	—
	5 ,,	++	++	+	T	—	—	—	—	—	—
	6 ,,	++	++	++	++	++	+	—	—	—	—
	7 ,,	++	++	++	++	++	+	—	—	—	—
	10 ,,	++	++	++	++	++	++	+	T	—	—
	13 ,,	++	++	++	++	++	++	+	T	—	—
	21 ,,	++	++	++	++	++	++	T	—	—	—
	24 ,,	++	++	++	++	++	+	—	—	—	—
	29 ,,	++	++	++	++	T	—	—	—	—	—
	5 weeks	++	++	++	++	T	—	—	—	—	—
	7 ,,	++	++	—	—	—	—	—	—	—	—
	9 ,,	++	+	—	—	—	—	—	—	—	—
	2½ months	+	—	—	—	—	—	—	—	—	—
	3 ,,	T	—	—	—	—	—	—	—	—	—
	4 ,,	—	—	—	—	—	—	—	—	—	—
4,974 Kabete Vaccine	1 day	—	—	—	—	—	—	—	—	—	—
	2 days	—	—	—	—	—	—	—	—	—	—
	3 ,,	—	—	—	—	—	—	—	—	—	—
	4 ,,	++	T	—	—	—	—	—	—	—	—
	5 ,,	++	+	T	—	—	—	—	—	—	—
	6 ,,	++	++	++	+	—	—	—	—	—	—
	7 ,,	++	++	++	++	+	T	—	—	—	—
	10 ,,	++	++	++	++	++	++	+	T	—	—
	13 ,,	++	++	++	++	++	++	+	T	—	—
	21 ,,	++	++	++	++	++	+	T	—	—	—
	24 ,,	++	++	++	++	+	T	—	—	—	—
	29 ,,	++	++	++	+	T	—	—	—	—	—
	5 weeks	++	++	++	++	T	—	—	—	—	—
	7 ,,	++	++	—	—	—	—	—	—	—	—
	9 ,,	++	T	—	—	—	—	—	—	—	—
	2½ months	+	T	—	—	—	—	—	—	—	—
	3 ,,	+	T	—	—	—	—	—	—	—	—
	4 ,,	—	—	—	—	—	—	—	—	—	—
4,927 Strain 19 Vaccine	1 day	—	—	—	—	—	—	—	—	—	—
	2 days	—	—	—	—	—	—	—	—	—	—
	3 ,,	—	—	—	—	—	—	—	—	—	—
	4 ,,	—	—	—	—	—	—	—	—	—	—
	5 ,,	—	—	—	—	—	—	—	—	—	—
	6 ,,	++	+	T	—	—	—	—	—	—	—
	7 ,,	++	++	+	T	—	—	—	—	—	—
	10 ,,	++	++	+	+	T	—	—	—	—	—
	13 ,,	++	++	++	+	—	—	—	—	—	—
	21 ,,	++	++	++	T	—	—	—	—	—	—
	24 ,,	++	++	+	—	—	—	—	—	—	—
	29 ,,	++	T	—	—	—	—	—	—	—	—
	5 weeks	++	—	—	—	—	—	—	—	—	—
	7 ,,	T	—	—	—	—	—	—	—	—	—
	9 ,,	—	—	—	—	—	—	—	—	—	—
	2½ months	—	—	—	—	—	—	—	—	—	—
	3 ,,	—	—	—	—	—	—	—	—	—	—
	4 ,,	—	—	—	—	—	—	—	—	—	—
4,972 Strain 19 Vaccine	1 day	—	—	—	—	—	—	—	—	—	—
	2 days	—	—	—	—	—	—	—	—	—	—
	3 ,,	—	—	—	—	—	—	—	—	—	—
	4 ,,	—	—	—	—	—	—	—	—	—	—
	5 ,,	T	—	—	—	—	—	—	—	—	—
	6 ,,	++	+	T	—	—	—	—	—	—	—
	7 ,,	++	++	+	+	T	—	—	—	—	—
	10 ,,	++	++	++	+	+	—	—	—	—	—
	13 ,,	++	++	++	+	T	—	—	—	—	—
	21 ,,	++	++	++	T	—	—	—	—	—	—
	24 ,,	++	+	T	—	—	—	—	—	—	—
	29 ,,	+	T	—	—	—	—	—	—	—	—
	5 weeks	++	T	—	—	—	—	—	—	—	—
	7 ,,	—	—	—	—	—	—	—	—	—	—
	9 ,,	—	—	—	—	—	—	—	—	—	—
	2½ months	—	—	—	—	—	—	—	—	—	—
	3 ,,	—	—	—	—	—	—	—	—	—	—
	4 ,,	—	—	—	—	—	—	—	—	—	—

T = Titre

TABLE II.

EXPERIMENT 2.

THE ANTIBODY RESPONSE OF CALVES TO SUBCUTANEOUS INOCULATION WITH 5 c.c. STRAIN 19 VACCINE (MINISTRY STRENGTH).

Calf No.	Interval after Inoculation.	Serum Dilutions.									
		20	40	80	125	250	500	1,000	2,000	4,000	8,000
5,649	1 day	—	—	—	—	—	—	—	—	—	—
	2 days	—	—	—	—	—	—	—	—	—	—
	3 "	—	—	—	—	—	—	—	—	—	—
	4 "	+	T	—	—	—	—	—	—	—	—
	6 "	++	++	++	++	+	+	—	—	—	—
	8 "	++	++	++	++	++	+	T	—	—	—
	18 "	++	++	++	++	+	T	—	—	—	—
	4 weeks	++	+	T	—	—	—	—	—	—	—
	5 "	++	++	+	T	—	—	—	—	—	—
	7 "	++	++	T	—	—	—	—	—	—	—
	9½ "	++	+	T	—	—	—	—	—	—	—
	3½ months	+	T	—	—	—	—	—	—	—	—
	4 "	—	—	—	—	—	—	—	—	—	—
5,637	1 day	—	—	—	—	—	—	—	—	—	—
	2 days	—	—	—	—	—	—	—	—	—	—
	3 "	—	—	—	—	—	—	—	—	—	—
	4 "	++	+	—	—	—	—	—	—	—	—
	6 "	++	++	++	++	++	+	T	—	—	—
	8 "	++	++	++	++	++	++	++	+	T	—
	18 "	++	++	++	++	++	++	T	—	—	—
	4 weeks	++	++	++	+	T	—	—	—	—	—
	5 "	++	++	+	T	—	—	—	—	—	—
	7 "	++	+	T	—	—	—	—	—	—	—
	9½ "	++	+	T	—	—	—	—	—	—	—
	3½ months	+	T	—	—	—	—	—	—	—	—
	4 "	—	—	—	—	—	—	—	—	—	—
5,517	6 days	—	—	—	—	—	—	—	—	—	—
	8 "	+	T	—	—	—	—	—	—	—	—
	18 "	++	+	T	—	—	—	—	—	—	—
	4 weeks	++	+	—	—	—	—	—	—	—	—
	5 "	++	+	—	—	—	—	—	—	—	—
	7 "	+	T	—	—	—	—	—	—	—	—
	9½ "	T	—	—	—	—	—	—	—	—	—
	3½ "	—	—	—	—	—	—	—	—	—	—

For convenience, the antibody response of calves 5649 and 5637 are discussed first. Positive returns were obtained on the 4th day, two days sooner than the calves which received the weaker Strain 19 vaccine in the previous experiment. Thereafter, agglutination titres rose rapidly to a high dilution. By the 18th day, the titres were on the decline and finally became negative four months after inoculation.

Calf 5517, for reasons not apparent, exhibited a poor response to vaccination as measured by demonstrable antibody production. Its serum reached a titre of 1 in 40 only, as against 1 in 2,000 in the case of calf 5637. A negative return was obtained 3½ months after inoculation.

Experiments on a field scale were now devised, and the co-operation of dairy farmers on three different farms obtained. On each farm a number of young heifer calves, grade or pure-bred, was selected. On two farms (A and B), the calves were inoculated subcutaneously with 5 c.c. of routine Kabete vaccine, and on the third farm (C), 5 c.c. of Strain 19 vaccine were used, prepared according to the Ministry of Agriculture's recommendations. The ages of the calves varied from 6–20 months at the time of inoculation and all had been weaned. Preliminary tests showed in all cases that the calves were negative to the agglutination test before receiving vaccine. Samples of sera were regularly obtained and subjected to the agglutination test. Tables III, IV and V record the results.

TABLE III.

EXPERIMENT 3. FARM A.

HIGHEST ANTIBODY TITRES FOLLOWING SUBCUTANEOUS INOCULATION WITH 5 c.c. ROUTINE KABETE VACCINE ON 16TH JUNE. 1943.

Calf No.	Age when Inoculated.	Intervals after Inoculation.																Remarks.
		26 days	9 weeks	18 weeks	22 weeks	6 mths.	7½ mths.	9½ mths.	11 mths.	12 mths.	14 mths.	16 —ths.	18 mths.	2 years	2¼ years	2½ years	3 years	
	months																	
1	19	250	20	sold														Sold, no history.
2	9	250	20	—	—	—	T	—	—	—	—	—	—	sold				" "
3	16	1,000	125	T	T	—	—	T	T	40	T	—	20	—	—	—	—	Calved normally, 23–3–45.
4	8	80	20	—	—	—	—	—	—	—	—	—	20	—	—	—	—	" " 24–4–45.
5	11	250	20	—	—	20	T	—	T	—	T	—	20	—	T	—	—	" " 15–5–46.
6	14	250	20	T	—	20	20	T	T	80	T	sold			—	—	—	Sold, no history.
7	10	250	20	—	—	—	T	—	—	T	T	—	—	—	—	—	—	Calved normally, 27–7–45.
8	16	250	125	20	T	20	20	T	T	20	T	—	—	—	—	—	—	" "
9	17	125	80	20	20	20	20	20	20	20	20	—	40	—	—	—	—	" "
10	14	250	20	—	—	—	T	—	T	20	20	T	T	—	—	—	—	" " 12–5–45.
11	11	80	20	T	—	—	T	—	—	—	—	—	T	—	—	—	—	" " 27–6–45.
12	10	80	—	—	—	—	—	T	—	—	—	—	T	—	—	—	—	" " 22–8–45.
13	14	250	40	—	—	T	T	T	—	T	T	T	T	—	—	—	—	" " 28–7–45.
14	12	125	20	—	—	—	—	—	—	—	—	sold						Sold, no history.
15	15	died																Died.
16	14	125	40	—	—	—	—	—	T	—	—	—	T	—	—	—	—	Calved normally, 23–2–45.
17	13	250	80	20	—	20	20	20	20	80	40	40	40	—	—	T	—	" " 25–4–45.
18	14	250	40	—	T	T	T	20	20	—	sold							Sold, no history.
19	14	250	80	—	—	—	—	—	—	—	—	—	—	—	—	—	—	Calved normally, 28–4–45.
20	12	1,000	80	—	—	—	—	—	—	—	sold							Sold, no history.
21	15	500	80	T	20	40	20	40	20	—	40	40	40	—	—	20	T	Calved normally, 25–2–45.

— = No demonstrable antibodies.

T = Trace of agglutination at a dilution of 1 in 20.

TABLE IV.

EXPERIMENT 3. FARM B.

HIGHEST ANTIBODY TITRES FOLLOWING INOCULATION WITH ROUTINE KABETE VACCINE ON 17TH JULY, 1943, 5 c.c. SUBCUTANEOUSLY.

Calf No.	Age when inoc'd	Intervals after Inoculation.																		Remarks.
		18 days	7 weeks	10 weeks	16 weeks	5 mths.	6 mths.	7 mths.	9 mths.	10 mths.	11 mths.	13 mths.	15 mths.	17 mths.	19 mths.	21 m ths.	2 years	2¼ years	2¾ years	
	months																			
4	6	250	250	80	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	Calved normally
6	10	250	125	80	—	—	—	—	—	—	—	T	—	—	—	—	—	—	—	" "
8	12	1,000	125	80	20	T	20	20	20	20	—	20	40	20	T	—	—	20	20	" "
10	8	1,000	80	40	T	—	T	—	—	—	—	T	—	—	—	—	—	—	—	" "
11	11	125	20	20	—	—	T	—	—	—	—	—	—	—	—	—	—	—	—	" "
13	12	250	250	80	T	—	T	T	T	—	—	20	T	T	T	—	—	—	sold	" "
14	9	250	250	125	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	" "
15	8	250	250	20	—	—	—	—	—	—	—	T	—	—	—	—	—	—	—	" "
17	8	250	125	40	—	20	20	20	—	—	—	—	—	—	—	—	—	—	—	" "
18	7	125	20	—	—	—	T	—	—	—	—	—	—	—	—	—	—	—	—	" "
19	7	250	125	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	sold	" "
20	6	80	20	80	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	" "

— = No demonstrable antibodies.

T = Trace of agglutination at a dilution of 1 in 20.

TABLE V.

EXPERIMENT 3. FARM C.

HIGHEST ANTIBODY TITRES FOLLOWING SUBCUTANEOUS INOCULATION WITH 5 c.c. STRAIN 19 (MINISTRY STRENGTH) VACCINE, ON 17TH MARCH, 1944.

Group A.		Intervals after Inoculation.									Remarks
Calf No.	Age when inoc'd.	2 wks.	4 wks.	7 wks.	3 mth.	5 mth.	7 mth.	9 mth.	1 year	1¼ year	
	month										
1	16	500	125	40	20	—	—	—	—	—	
2	12½	125	80	40	T	—	—	—	—	—	
3	12	250	125	40	T	—	—	—	—	—	
4	11½	250	80	20	T	—	—	—	—	—	
5	10½	125	125	80	T	—	—	T	—	—	
6	10½	1,000	250	80	20	—	—	—	—	—	
7	10	500	125	40	T	T	—	20	—	—	
8	10	500	125	40	40	T	—	T	—	—	
9	9½	40	80	—	T	—	—	—	—	—	
10	9	250	125	40	20	—	—	T	—	—	
11	9	250	125	20	20	—	—	—	—	—	
12	9	500	125	40	T	—	—	—	—	—	
13	9	125	125	40	20	T	—	—	—	—	
14	16	250	125	125	40	—	—	—	—	—	
15	9½	500	125	40	40	T	—	—	—	—	
16	9	250	80	40	20	T	—	—	—	—	
17	9	250	80	40	T	—	—	—	—	—	
18	8½	500	125	40	20	—	—	—	—	—	
19	9	250	125	80	T	—	—	—	—	—	
20	8½	500	250	125	20	T	T	—	T	—	

Group B.		Intervals after Inoculation.										Remarks
Calf No.	Age when inoc'd.	2 wks.	4 wks.	2 mth.	2½ mth.	3½ mth.	5½ mth.	6½ mth.	8 mth.	1 year	1¼ year	
	month											
2	15	250	80	40	20	T	—	—	—	—	—	
3	15	500	125	80	40	40	40	40	20	—	—	
4	15	80	80	40	20	20	—	—	—	—	—	
5	13	250	80	80	20	T	—	—	—	—	—	
6	13	250	80	80	20	T	—	—	—	—	—	
7	12	500	125	125	125	20	40	20	—	—	—	
8	10	80	80	40	20	T	—	—	—	—	—	
9	10	250	80	40	20	T	T	—	—	—	—	
10	9	80	80	40	20	T	—	—	—	—	—	
12	8	80	80	40	—	—	—	—	—	—	—	
14	15	500	125	125	40	20	T	—	—	—	—	
15	14	80	80	40	T	T	—	—	—	—	—	
16	17	80	80	40	T	—	—	—	—	—	—	
17	16	500	125	125	80	40	40	40	20	—	—	
18	14½	250	80	80	20	—	40	20	T	—	—	
19	12	250	80	80	T	T	—	—	—	—	—	
20	14	500	80	80	20	T	—	—	—	—	—	
21	13½	250	125	80	40	—	—	—	—	—	—	
22	13½	80	80	40	T	—	T	—	—	—	—	
23	10	250	80	40	20	—	T	—	—	—	—	
24	10	250	125	80	40	20	20	—	—	—	—	
25	10	500	125	40	80	20	40	—	T	—	—	
26	9½	250	125	80	80	T	20	—	—	—	—	
27	9½	250	125	80	40	T	—	—	—	—	—	
29	16	250	125	80	40	—	40	—	20	—	—	

— = No demonstrable antibodies.

T = Trace of agglutination at a dilution of 1 in 20.

Discussion

A criticism frequently levelled at the use of live abortion vaccine is that the presence of antibodies following inoculation is liable to interfere with the interpretation of the agglutination test should it be desired subsequently to investigate the possibility of the presence of natural infection. It is important to know, therefore, how soon the sera of calves inoculated with live vaccine will return to negative, what proportion do so only very slowly over a prolonged period, and to what extent the agglutination test may, therefore, be invalidated. From these points of view, the results of the experiments detailed in Tables III, IV and V are of some interest and value.

Amongst the calves on Farms A and B, where Kabete vaccine was used, the highest titre recorded was 1 in 1,000. On farm A, 12 calves out of 19 (63 per cent) were completely negative after 18 weeks, whilst about 40 per cent continued to show weak, irregular reactions for periods of up to 18 months. On Farm B, 9 calves out of 12 (75 per cent) were negative after 16 weeks and 16 per cent failed to become consistently negative until 19 months had elapsed. The first completely negative returns throughout were recorded 2 years (farm A) and 21 months (farm B), respectively, after inoculation.

From these results it would appear that the majority of inoculated calves quickly become negative to the agglutination test and should occasion arise, in subsequent months, to re-examine them, the agglutination test will give a true indication of the presence or absence of natural infection.

Of more importance is the significance of the persistent, if irregular, weak reactions exhibited by certain calves over prolonged periods. This is by no means unusual and has been observed by many workers. It appears to be an individual characteristic inherent in the make-up of a certain proportion of calves. In order to assess the possible interference with the evaluation of subsequent agglutination tests, the details of the test must be understood. Three dilutions of sera are made, 1 in 20, 1 in 40 and 1 in 80. These are mixed with standard amounts of *Brucella abortus* organisms and incubated at about body heat for 24 hours. If antibodies are present, they agglutinate or clump together the *Brucella* organisms in characteristic manner. The higher the antibody content of the serum, the higher the dilution at which it will continue to agglutinate. If agglutination occurs in all three dilutions, this is known as a "strong positive", and is characteristic of the presence of active, natural infection or recent inoculation with live vaccine. When agglutination occurs at the smaller dilutions only, and not the higher, this reaction is recorded as "weak positive" or "doubtful" and where the history of the herd is unknown, the owner is usually asked to repeat the sample for confirmation.

It will have been observed in experiments 1 and 2 (Tables I and II), that the rise in antibody titre following inoculation was very sharp indeed. Within a space of 48 hours titres jumped from negative to figures well over 1 in 80. Decline in titre, however, was slow and protracted over a long period. It follows, therefore, that when a serum agglutinates only at 1 in 20 or 1 in 40 and is recorded "weak positive" or "doubtful", the chances that this represents the commencement of active infection are very unlikely. Such reactions almost invariably indicate a return to normality following infection some months previously.

Returning now to a consideration of those animals (particularly numbers 3, 5, 9, 17 and 21, farm A, and 8 and 13, farm B) which did not become completely negative until 18 months to 2 years after vaccination, it will now be appreciated that the presence of small amounts of antibodies in their sera need not invalidate agglutination tests designed to reveal the presence of natural infection subsequent to vaccination. On only two occasions were titres of 1 in 80 recorded, which, in routine testing, could be considered as "strong positive", and indicative of the presence of active infection. If it were known that such animals had been inoculated previously, the sera could be diluted further when it would be found that 1 in 80 was actually the end point and, therefore, almost certainly not indicative of active infection. A re-test a week or two later would confirm this since the titres would have dropped again or even become negative (*see* tables). It is incumbent upon stockowners, therefore, when submitting blood samples from animals previously vaccinated, to mention this fact so as to make the results of the agglutination test more intelligible.

To summarize the results from farms A and B, it may be said that an intelligent use of the

agglutination test would have made it possible on both farms to discover the introduction of natural infection at any time after 4–5 months following vaccination.

Turning now to the results from farm C, where Strain 19 vaccine was used, it will be seen that the production and subsequent decline of antibodies followed the same general course as was observed on farms A and B. The results are rather more sharply defined, however, in that there was a more rapid and general return to negative, with fewer cases of prolonged, weak reactions. In Group A, the majority were negative after 5 months and the remainder showed only a trace of reaction. In Group B, the general return to negative was rather slower. In both groups negative returns were obtained 12 months after vaccination.

To compare now the two vaccines, it will be seen that Strain 19 compared favourably with Kabete vaccine in that a more rapid and general decline of demonstrable antibodies occurred, and it would seem likely that a complete return to negative to the agglutination test can be expected, if not invariably, at least in the great majority of cases, in 9–12 months after inoculation, with this vaccine. Using Kabete vaccine, there was a definite tendency for some individuals to remain positive for a much longer period, although, as already explained, not in sufficient strength to interfere with subsequent routine testing.

The two vaccines stimulated the production of antibodies to about the same level and in so far as immunity is proportional to the intensity of antibody production, there would appear to be little to choose between the two vaccines.

Regarding the subsequent history of the vaccinated calves, it can only be said that, apart from some that were sold and whose histories were not obtained, all became pregnant and gave birth to healthy calves after normal gestation periods.

Finally, it must be reiterated that these results throw light on only one aspect of the comparison between the two vaccines, and, as already indicated, many other experiments await fulfilment before it can be stated with confidence that one or other is the most suitable for calfhood vaccination in Kenya.

ACKNOWLEDGMENTS

I wish to record my grateful thanks to those stockowners who placed at my disposal the calves used in the field trials and submitted blood samples for testing, namely Mr. A. J. Simpson of Nakuru, Capt. D. Sharp of Lamuria and Mr. Hallowes of Ondiri Farm, Kikuyu. I also wish to thank Miss Jean Sharp for much technical assistance, and the Director of Veterinary Services for permission to publish this paper.

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KHAT

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History

Khat, Cafta, Quat or Qat, Arabian, Abyssinian or African Tea, is a stimulant narcotic whose leaves are used in a fresh state as a masticatory, or after drying are infused and drunk like tea.

The earliest known reference to Khat is that contained in an Arabic manuscript written by Abd al Kadir in 1587 and preserved in the Bibliothèque Nationale, Paris [1], in which it is stated that in about 1454, a mufti of Aden, Sheik Gemaleddin Abou Muhammad Bensaid, introduced coffee drinking into Aden from Ethiopia and that lawyers, students, and artisans, as well as those who worked or travelled by night, took to drinking coffee in place of another drink which was then becoming popular, and which was made from the leaves of a plant called *Khat* or *Qat*.

The first Europeans who mention and collected specimens of Khat were the Swedish physician Peter Forsskal (1736–63), and the Hanoverian geographer and traveller Karsten Niebuhr (1736–1815), who were both sent by Frederik V of Denmark on a scientific expedition to the East, especially to Egypt and Arabia [2]. Forsskal described Khat, which he found in Arabia, under the botanical name *Catha edulis*, in the family Celastraceæ, in his *Flora Aegyptiaca–Arabica* (posthumously published in 1775 by his friend Niebuhr).

Botany

Catha edulis (Fig. 1) is a glabrous evergreen shrub, ten to twenty feet tall, but in favourable localities it becomes a slender tree up to 80 ft. tall with a trunk over two feet in circumference at breast height; the bark is fairly thin, smooth, a pale greyish-brown in colour; the crown is pointed, narrowly pyramidal in outline, usually branching all the way up the stem, of which more than one is often produced, especially when growing in the open. The young leaves are crimson-brown, glossy, becoming dark yellow-green, glossy, and leathery with age. They are opposite on compressed twigs, lanceolate or even oval in shape, with repand-serrate margins, shortly stalked; and they vary greatly in size, ranging from 3 to 12.2 cm. in length by 0.5 to 6.7 cm. in breadth. The flowers are small and white, and are produced in axillary cymes from the leaf-axils towards the ends of the younger branchlets. There are five sepals, equal, deeply toothed, and five oblong petals. The disc is saucer-shaped with a crinkled margin. The ovary is borne in the centre of the disc, but not enveloped by it and is 3-celled, with two erect ovules in each cell. The style is terminal, the stigma very short-stalked and 3-lobed. The fruit is a dark brown, oblong, 3-locular capsule up to 1 cm. long containing one to three seeds. The seed has a small brown papery wing at the base and is 7 mm. long over all, the seed itself being 3 mm. long, oblong, rich reddish-brown, and finely warted, especially near the apical margin [3].

Catha edulis was first figured in Lindley's *Vegetable Kingdom* published in London in 1846, it was also figured under the name *Celastrus edulis* Vahl in 1847 in Ferret and Galinier's *Voyage en Abyssinie Botanical Atlas*. Under the name *Catha Forskalii* A. Richard it was again figured and described in 1847 in Richard's *Tentamen Flora Abyssinicæ*, it having been found wild in Ethiopia by R. Petit and Richard Quartin-Dillon between 1838–43 during a French scientific expedition.

The same plant was discovered in South Africa [4] and described under the name *Methyscophyllum glaucum* by Ecklon and Zeyher in their *Enumeratio Plantarum Africæ Australis Extratropicæ* p. 152 published in 1834.

Distribution and Ecology

In Southern Arabia, from where *Catha edulis* was first recorded, it is not found wild but is cultivated along with coffee. The best is found on the terraces of Jabel Sabir, near Ta'izz in the Yemen where the rainfall is comparatively high [5]. It is thought to have been introduced into Arabia by the Abyssinians between the first and sixth century during their re-conquest of that country. Sometime before this they had migrated from Arabia to the opposite coast of Africa [6], from whence they flowed back and settled in southern Arabia when they overthrew the Himyarite kings and established a dynasty of their own about A.D. 300.

The plant is now known to extend throughout East Africa from Ethiopia and Somalia down to the Transvaal, Natal and the Cape in South Africa; it is usually found growing gregariously. Under natural conditions Khat grows in and on the margins of dry evergreen

forest and mist forest, and in Tanganyika it is often associated with East African Cedar, *Juniperus procera* and Yellow-wood or Podo, *Podocarpus* spp.

In Uganda [7] it has been collected in the Kigezi, Southern Karamoja and Bugishu Districts, from the Muhravwa, Debasien and Elgon Mountains. It ranges from 6,800 to 8,000 ft. altitude, where it flowers and fruits between October and February.

In Kenya ([8] and [9]) it appears to have a wider distribution, having been collected in the Northern Frontier District, the Kenya slopes of Elgon in the west, Mt. Kenya to the Chyulu Hills in the south-east, at altitudes ranging between 4,000 and 8,000 ft.

In Tanganyika Khat has a wide distribution, from Mt. Hanang and Mt. Ufiome by way of the Pare and West Usambara Mountains in the north, the Southern Ngurus, the Makonde Plateau, the Iringa District, and south to Rungwe Mountain and Mbosi in the south-west, with a range from 4,000 to 7,000 ft. in altitude. Its flowering and fruiting period ranges from February to September.

In Nyasaland [10] it has been collected in the Dedza District; on Mt. Mlanji, and the Blantyre District.

It has also been collected in Gazaland [11] on the Southern Rhodesian and Portuguese East African borders; at Chirinda where it is called Chirinda Redwood. There it is described as one of the largest forest trees, very rough barked with red, handsome durable timber. It here ranges in altitude from 2,000 to 4,000 ft. and flowers and fruits between April and October.

In Southern Rhodesia [12] it has been recorded from Salisbury and Umtali.

Native Uses

The use of the leaves of *Catha edulis* as a masticatory are well known to the Arabs, Somalis, Abyssinians and Masai, and during the recent war knowledge of such use has spread to other East African tribes through the African troops meeting the custom during their war service in Kenya and Somalia.

The young leaves and twigs are usually chewed fresh but in Ethiopia [8] they are also eaten as a paste mixed with honey, and in Tanganyika they are sometimes taken with sugar.

In Arabia the leaves may be dried and smoked like tobacco. In South Africa [13] they are used to make a drink like tea which was used by the Bushmen as a stimulating beverage called Bushman's Tea. An infusion of the leaf was used in coughs, asthma, and other diseases of the chest. The shoots were also used by the Bushmen as a specially nourishing food.

In Tanganyika the leaves and roots are used to cure influenza, and the roots are also eaten to cure stomach-ache. In Arabia it is also claimed that the leaves are a protection against Bubonic plague.

Both in Kenya and Tanganyika the stems are used for building native huts.

In Tanganyika the wood of *Catha edulis* is used for making native spoons and combs, and it is said to be an excellent fuel tree.

FIG. 1

Catha edulis Forssk. A, branchlet with flowers and fruits; B, cross-section through an unopened fruit; C, an opened fruit with one of the valves removed showing the seeds; D, cross-section through an opened fruit; E, a seed. (After Loesener in Engler and Prantl, Nat. Pflanzenfam.)

Native Names for Khat

UGANDA.—*Musitate* (Lumwege).

KENYA.—*Kat* (Somali); *Mirungi, Muirungi* and *Miraa* (Kik.); *Ol Meraa* (Mas.); *Liss* (Mar.); *Tumayot* (Dor.); *Muraa* (Mer.); *Mairongi* (Mt. Kenya); *Meongi, Maonj* and *Miungi* (Kamb.).

TANGANYIKA.—*Mlonge* (Swah.); *Mulungi* (Somali); *Warfo, Warfi* and *Waifo* (Mbulu); *Seri* (Fiome); *Mandoma, Mwandama, M'mke* and *Mfeike* (Shambaa); *Mzengo* (Nguru); *Msekera* (Kilongo, Uzinza); *Nangungwe* (Mwera); *Mhulu, Muhulu* and *Muhulo* (Hehe); *Liruti* (Hehe, Fuagi); *Msabukinga* (Kinga); *Msuruti, Msuvuti* and *Mbungula mabwe* (Rungwe); *Mira* and *Mbungula mabwe* (Tukuyu); *Ikwa* (Nyika).

NYASALAND.—*Mutsawari* (Mlanje); *Mdimamadzi* (Dedza).

GAZALAND.—*Mutsawhari* (Chendao).

CULTIVATION OF KHAT

Besides being in a wild state in Ethiopia, Khat is also cultivated, especially in the district of Harar. It is cultivated by the Kikuyu in Kenya and at one time was grown by a small settlement of Wanyamwezi at Kwezinga in the Mkuzi Valley in the West Usambaras, Tanganyika. At Amani, in the East Usambaras, *Catha edulis* was planted by the Germans in April, 1913, at 1,500 ft. altitude, in mixture with Silky Oak, *Grevillea robusta* A. Cunn. When measured in June, 1947, it had reached a height of 45 ft. with a circumference of 2 ft. at breast height. The trees are in good condition in spite of the relatively low altitude at which they are planted, but several have produced more than one stem.

Catha edulis has been successfully cultivated in Bombay and is established in Ceylon; it has also been introduced into France and the U.S.A. and grows well in the south of both these countries.

In Southern Arabia ([5] and [14]) it is cultivated at altitudes between about 5,000 and 9,000 ft. on mountain terraces. It is said to be grown from cuttings which are left to develop for three years; the leaves are then stripped, except those from a few buds, which develop next year into young shoots. These latter are cut and sold in bunches under the name *Khat mubarak*; next year, on the branches cut back, new shoots grow, and these are removed and sold as *Khat malhani* or second year Khat, which commands the highest price. The bushes are then left to grow for three years when the process is repeated. Other accounts say that each plant produces three crops a year.

For chewing, only the young leaves attached to young branchlets 6–8 inches long are gathered, and they are bound into small bundles which in turn are wrapped in grass to protect the twigs from withering. In this manner Khat is kept in good condition for about a week and is often transported to market over long distances [5].

KINDS OF KHAT

To the connoisseur, Khat is like tea in that a number of kinds are recognized. Besides *Khat mubarak* and *Khat malhani* already referred to, Vaughan [15] mentions two in Aden, *"Tubbare Kat"* and *"Muktaree Kat"* and says the latter fetches the lower price. Actually, according to Glover [16] there are said to be seven different kinds of Khat obtainable in Aden. They are:—

(1) Barehe, with long branchlets; stimulates urinary activity.

(2) Dalei, leaves only; shoots cut very short; very potent.

(3) Dalil, short branchlets; large leaves at top; not very potent.

(4) Makdare, very large leaves.

(5) Matani, thick branchlets.

(6) Sharau, long branchlets, very potent; also said to be an aphrodisiac.

(7) Ti-isi, short branchlets, sweet tasting; not very potent but considered to be the best kind.

In Ethiopia and Somalia [16] the Abyssinians and Somalis distinguish between six different sorts of Khat. They are:—

(1) Balhaf, large leaves.

(2) Gardel, red branchlets.

(3) Gode, thin branchlets with small leaves; said to be very potent.

(4) Hagafo, shoots cut short from small plants.

(5) Sam-sam, short shoots; small leaves; very potent.

(6) Sum-sum, medium branchlets.

Khat addicts are certainly particular in what they use. Recently a Somali community found itself deprived of its supplies which were normally obtained from a neighbouring territory where it is cultivated. Alternative sources were tried, including Khat obtainable from wild plants and their opinion of the latter was that it was useless.

In the Yemen [5] taxes are levied on the cultivation of Khat, and this produces a considerable revenue for the government.

In Aden [15] in the 1850's it is recorded that an average of 280 camel-loads were brought in to Aden annually, and that the market price was 1¼ rupees per parcel (containing about 40 twigs), and that the exclusive privilege for selling it was farmed by the government for 1,500 rupees per annum.

It was sold in Ethiopia, Somaliland and on native markets in and around Nairobi in Kenya and there is no doubt that it can be bought in a few towns in Tanganyika and in Zanzibar wherever Somalis and Arabs are to be found.

Chemical Composition

The first chemical investigation of *Catha edulis* appears to be that carried out by Flückiger and Gerock [17], who reported to a British Pharmaceutical Conference in 1887 that they had isolated the alkaloid cathine from the leaves. In the same year Paul [17] also published some work on this subject, and in 1891 Mosso [17] obtained an alkaloid called Celastrin from Khat leaves. Beitter ([17] and [18]) followed in 1901 with a paper in which he described the isolation of cathine, but he also obtained a tannin and a strongly odorous volatile oil from leaves, and 50 per cent fixed oil from seeds. In 1912 Stockman [18] reported that he had isolated three alkaloids, which he named cathine, cathinine and cathidine.

According to Beitter [18] the formula for cathine is $C_{10}H_{18}ON_2$ and it crystallizes in needle-like, bitter odourless crystals, soluble in alcohol, chloroform, ether and dilute acids. Wolfes [18] found the product described by Stockman to be identical with *d*-Nor-*iso*-ephedrine, with the chemical formula $C_6H_5.CHOH.CH.(NH_2).CH_3$. This alkaloid is a muscle poison, and has a paralysing action on the brain, spinal cord and peripheral nerve centres. The amount of cathine in the leaf ranges from 0.03 to 0.08 per cent, too small to be of commercial value.

The alkaloid cathinine is a white, amorphous, bitter substance, freely soluble in water, alcohol, chloroform, acetone, ethyl acetate, and amyl alcohol, slightly soluble in benzene and ether, insoluble in petrol and benzin. It stimulates the spinal cord and paralyses the nerves.

Cathidine is a white, amorphous, bitter powder, insoluble in water, soluble in alcohol, benzenene, chloroform, ether, acetone, ethyl acetate and amyl alcohol. It is said to be a mild nerve stimulant and muscle poison.

Fig. 2

Catha edulis Forssk. Terminal growth.

The Effects of Khat on Man

As already stated Khat is a stimulant narcotic. It is used by a very large proportion of the population of south-west Arabia [5], the Somalis and Abyssinians and to a certain extent by the natives in East Africa. Usually a branchlet of about ten leaves weighing less than a gramme is chewed.

Those who indulge in Khat claim the most varied and often contradictory properties for the drug, but all are agreed that it produces wakefulness with a feeling of well being and mental alertness. It induces thirst, and water is drunk at intervals during Khat chewing. Taken in excess Khat induces symptoms which to an observer simulate alcoholic intoxication [5]. According to the British Pharmaceutical Codex [19] it is said to dilate the pupils of the eyes, and to excite the whole of the central nervous system.

Two cases of insanity and one of poisoning due to excessive Khat chewing have recently been observed in Kenya. Of those of insanity, Carothers [20] reports that one was a Somali, the other a Mnyamwezi (a native of the Tabora District of Tanganyika) both males. The symptoms in both cases were mild mania, with some schizophrenic symptoms superadded especially in the case of the Somali. Both were excessively and effusively polite, but this is usual with the described effects of moderate doses. Like most drug addicts they quickly recovered when unable to obtain Khat.

In the case of poisoning, an elderly Arab who had consumed large quantities of Khat was admitted to the Wajir Hospital, in the Northern Frontier District. Heisch [21] reports on the case as follows:—

"He appeared to be in a highly excitable state of mind, and had lost the power of articulation. He was unable to walk, and his limbs moved periodically in a spasmodic and jerky manner."

"On examination: The eyes were wide open and staring. The pupils were normal and equal in size, and reacted sluggishly to light and accommodation."

"Upper and lower limbs: Both legs and arms were spastic and resisted passive flexion and extension. Knee and ankle jerks were not exaggerated. Ankle clonus could not be elicited. The plantar reflexes were equivocal."

"The sensory system: The patient was very sensitive to external impressions; and sudden noise in the vicinity caused him to groan and twitch his limbs. Hyperæsthesia was marked all over the body; a touch with a pin caused pain as shown by the facial expression, and was accompanied by twitching of the adjacent muscles."

"An attempt to elicit the abdominal reflexes, caused violent generalized twitching of the abdominal muscles and a touch on the forehead caused twitching of the whole face. Opisthotonus was not observed."

The patient was under observation and treatment for four days during which he remained in a coma, and then he died.

Various types of legislation against Khat have been in force in British Somaliland since 1921 and restrictive legislation has recently been introduced into Kenya where the use of Khat has been on the increase during the past few years.

Properties of the Timber

The wood of *Catha edulis* is pale golden-yellow to dark brown, weighing 42 lb. per cubic foot when air dry. It is lustrous, very straight-grained, fine and even in texture, moderately hard and strong. It saws and planes well, giving a smooth finish and polishes highly without filling, and because of these factors and the handsome appearance of its wood it is suggested as being suitable for cabinet making [7].

Its wood is said to make a good pulp and might be used for making a very high class blotting paper.

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KROMNEK DISEASE

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Attention is called to the virus disease, known in South Africa as Kromnek, since there is good reason for believing that it has become established in the south-west of Tanganyika Territory. Until now the disease on this Continent has been confined to South Africa and Southern Rhodesia. The evidence for its presence in Tanganyika is based on observations made in the Southern Highlands Province earlier this year, where two plants of tobacco and two fields of sunflower showed symptoms indistinguishable from those of kromnek. Because of the serious nature of that disease it is considered advisable not to wait for full confirmation of the nature of the disease in these crops, but to issue this warning, particularly to farmers and gardeners in the affected area and to prospective importers of plants from there. During the past year herbaceous ornamental plants have not been allowed entry into East Africa from countries in which the disease is endemic, in an endeavour to keep out the disease.

Reference must be made here to the names "Tomato spotted wilt" and "Tobacco ring-spot". These diseases and some others are now considered to refer to the same virus and to include kromnek. The distinctions were originally based on differences in host reaction, symptoms and other criteria, but these are now accounted for by the existence of strains of the virus organism. The name generally given to the virus group is "Tomato spotted wilt", and the other names, including kromnek, are usually given as synonyms. The name kromnek is used in South Africa, and since the strain or strains in Tanganyika are more likely to be similar to those in South Africa than to others, the name kromnek is used here meantime.

The disease under various names and on various host plants is recorded from South Africa, Southern Rhodesia (on dahlia) north-east Europe, parts of the United States and Canada, Brazil, the Argentine, Puerto Rico, Australasia and probably the Central Provinces of India.

The disease in tobacco has been recorded in several countries under the names Ring-spot, Kromnek, Wilt, Corcova, etc. Records of virus disease in sunflower are as follows. "Mosaic" is recorded in India and the Argentine, but without comment, and it is uncertain what diseases are referred to. Holmes [3] records sunflower as a host of Tobacco ring-spot, while in South Africa [2] the disease on sunflower is referred to as kromnek or mosaic.

Disturbing features of kromnek are firstly, that the host range is wide and includes many economic plants and a number of weeds; secondly, the virus can infect all parts of a susceptible plant, with the important exception of the seeds, but including tubers and bulbs; thirdly, the virus can be carried by thrips and aphids, and it may be spread by these before its presence in an area is suspected.

Although the tobacco in which the disease was observed consisted of only two plants, such isolated occurrences are not unknown elsewhere. The identification was made by Mr. K. B. Louwrens, Tobacco Officer, who has had considerable experience of the disease in South Africa.

The occurrence of a mosaic in sunflower was observed by the writer. The circumstances under which this disease was observed were as follows. A half-acre field of sunflower plants, two-and-a-half months old, showed about one-third seriously affected with mosaic. All the plants were taken up and burned. A hundred yards away was a field of older sunflowers extending to thirty acres. Mosaic symptoms were milder, having apparently started at a later stage in the growth of the plants than in the first field. A comparatively small number of these plants were affected. The farmer agreed to destroy affected ones as they were observed. No other crops were being grown in the immediate neighbourhood of the sunflower, with the exception of a small native plot of tobacco. The latter and a large number of garden plants two miles away were apparently still free from the disease. The symptoms in the sunflower are given below.

The insect vectors of the virus vary to some extent in different countries; those recorded are four species of the thrips Frankliniella, *Thrips tabaci* and *Aphis persicae*. A study of the crops and weeds and of the insect vectors will be made in the Southern Highlands Province next growing season.

Host Plants of the Virus

Host plants of the virus under its various names now total over two hundred, and new hosts are continually being recorded. Some examples are given below.

Among herbaceous crop plants are the following: tobacco, sunflower, potato, tomato, egg-plant, chilli, cape gooseberry, pineapple ("pineapple yellow spot"), and among vegetables are cauliflower, celery and cos lettuce.

Among cultivated trees and shrubs susceptible to the disease are: tree tomato, *Cassia laevigata, Cestrum* sp. and *Ribes* sp.

Herbaceous ornamentals include many host plants such as: dahlia, tropaeolum, antirrhinum, phlox, primulas, salvia, aster, schizanthus, chrysanthemum, zinnia, begonia and many others.

Wild host plants include *Datura* spp., black jack, *Erlangea tomentosa*, African violet (*Saintpaullia ionantha*), sow-thistle, *Nicandra physaloides*, basil, and screw pine (Pandanus).

There appears to be no record of groundnut being naturally infected in the field, but it was recently stated [6] that in the Argentine groundnut was more or less susceptible in inoculation experiments with the juice of affected plants. In view of the importance of that crop in East Africa, transmission studies will be advisable.

Control Measures

There appears to be little likelihood of eliminating the disease once it has become established in a country. Control measures which can be undertaken are as follows. In the first place infective material must be destroyed by burning; this is to prevent the insect vectors from feeding on such material and carrying the virus to healthy plants or healthy fields. Living plants, including cuttings, tubers and bulbs should not be moved from an endemic area to clean areas unless they are to be used as food. In the case of potato there is always a risk of peelings reaching the ground and producing new plants, but the chance of an infected potato tuber producing a diseased plant is said to be small [8]. Dahlia tubers on the other hand are dangerous.

In South Africa it is the custom in endemic areas to plant out tobacco, tomatoes, etc., at twice the normal density, either by doubling the plants per hill or by halving the normal planting distance. Affected plants are taken up as they are observed, and after four to eight weeks any excess plants are removed. Also in South Africa it has been found that the thrips vector does not spread the disease from one tobacco plant to another, and that infection almost invariably comes from some plant other than tobacco. Tobacco fields and their immediate neighbourhood are kept as free as possible from other growing plants, either cultivated or weeds.

Symptoms on Various Host Plants

With the exception of the disease in sunflower, the following descriptions are taken from the literature. Mr. K. B. Louwrens, however, provided (*in litt.*) some useful information on the disease in tobacco. Symptoms in plants in general are: stunting and cessation of growth; the head of a plant may bend over; leaves may be much reduced in size, be malformed and distorted, and may have blisters or bulges on the surface; they may be mottled or show concentric markings. Flowers may be much reduced in size and fruiting seriously affected.

Tobacco [7], [8].—The following notes are taken largely from Dr. K. M. Smith's published accounts. The early plantings are usually affected most. Symptoms vary but examples are given below. Concentric rings may appear on the leaves, sometimes in close connexion with the veins, and their presence gave rise to the name Ring-spot. At a later stage the rings increase in number, while decreasing in size. If the plant is not killed, the ring formation may give way to a necrosis along the veins. These symptoms are distinguished by K. M. Smith as a less virulent form of the disease than those to which the term "Scorch" is more appropriately applied than Ring-spot. Scorch is said to be fatal to about fifty per cent of seedlings in which it develops. Here an early symptom is a clearing of the veins of the younger leaves, the veins becoming yellow and strongly outlined, and the progress of the disease is then more rapid. The leaves lose their green colour and turn dark grey to almost black and appear scorched; they may become twisted and distorted. The scorch may be confined to one side of a leaf.

The plant may now die down, completely, or with the exception of the central shoot. Growth in the latter case may be resumed for some weeks when the plant may again show severe symptoms and collapse. K. M. Smith refers also to a third type of symptom, in older plants. This occurs when the scorch has not proved fatal. Successive new shoots are produced but are killed, some of the leaves

KROMNEK DISEASE IN UPPER PARTS OF SUNFLOWER PLANTS

having brown lesions and sometimes concentric rings on the stem. Finally such a plant may reach a height of two or three feet with clusters of dead shoots, though the apex may survive and even produce flowers and seed.

Sunflower.—In Tanganyika, symptoms were observed in plants two-and-a-half months old (*see* photos). About thirty per cent were affected; they were smaller than normal and showed the heads characteristically bent over in most. The flower-heads were either non-existent or were only up to an inch in diameter. The leaves and upper part of the stems were unusually hairy; the stems also had dark stripes, especially on the side to which the head inclined. Vascular bundles were black. The upper stems showed splits, and cracks were seen in petioles and veins in some leaves. The first symptoms were seen in the leaves; the lower leaves appeared normal, but the disease became more intense towards the top of a plant, where the internodes were short and the leaves were bunched. Many of the leaves were abnormally small; many were distorted and showed variegation in colour, yellowish and pale green areas or mottling between the veins. One leaf was distorted into a vase shape. Some of the leaves showed blisters or bulges on their surface. There were no leafy outgrowths, enations, on the veins.

Potato [7], [8].—The first symptom in potato is the appearance of pale round spots, around which a red ring forms. These spots decay into irregular necrotic lesions. The latter also appear on the stems and petioles. Tubers of affected plants become hard and the flesh is clear and glassy. Such tubers, when planted, however, give rise usually to healthy plants.

Tomato [7], [8].—The leaves of affected plants become stiff and tend to curl slightly downwards and inwards; veins of the youngest leaves become slightly thickened. Bronzing and necrotic spots appear, often with a ring-spot pattern. The plants at this stage may be stunted and growth may stop. Concentric ring-like marks appear on the fruits. The symptoms appear first in the young leaves and the disease may develop quickly. Young seedlings may be killed, but older plants may survive and show a characteristic mottling.

Dahlia [1], [8].—According to Miss A. F. Hean in South Africa, dahlias affected by kromnek show "clear patterns of concentric rings or wave-like markings in light brownish white against the dark green of the leaves. These markings are generally found on the lower leaves of the plants, the upper leaves being faintly mottled with yellow or being apparently healthy".

For symptoms in other plants the reader is referred to the literature cited.

The above account is of necessity a preliminary report but the potential seriousness of the disease warrants its publication at this stage.

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SOME STUDIES ON CULTIVATION PRACTICES, FOOD CROPS AND THE MAINTENANCE OF FERTILITY AT THE COTTON STATION, NYASALAND

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The cotton industry in Nyasaland is one of African peasant growers, and the work at the Cotton Experiment Station is primarily concerned with cotton problems. But cotton is not grown as a mono-culture, and the chief native food crops of the area are included in the rotation. There is also the universal problem, especially important in Africa, of maintaining and improving soil fertility. This article is not directly concerned with cotton problems, and gives a summary of general investigations that have been undertaken since the Cotton Station was opened in 1930.

Situation, Ecology and Soils

The Cotton Station is situated at Chitala, some 14 miles inland from Domira Bay, on the plain bordering Lake Nyasa. It lies on about latitude 13° S. and at an elevation estimated at 1,985 feet above sea level. Its lands are close to the main fault system on the western side of the Rift Valley, and immediately to the west of them are the foot-hills, and further back the main escarpment which forms the dominant feature on the landscape.

The natural woodland of the lake shore plain is an *Albizzia-Acacia-Combretum* association averaging 20–30 feet in height, with a certain number of larger trees mainly *Adansonia digitata, Sclerocarya caffra* and *Cordyla Africana.* As the land rises to the foot-hills, and on small elevations in the plain, *Brachystegia* spp. and *Isoberlinia* spp. become the dominant trees. The soils on which the latter association occurs are not very fertile, and they are not cultivated if better soil can be found. In the *Albizzia-Acacia-Combretum* association the soil is generally deep and fertile and has been mainly derived from schists of the metamorphic basement complex; there are heavy soil patches which appear to derive from sedimentary deposits surviving the denudation following the rifting, and allied to the Dinosaur beds of North Nyasa. The soils of the Station are a complex of residual and colluvial soils derived from the schists, and modified by admixture of soil derived from Dolerite dykes forming part of the main fault system, and there are patches of the sedimentary type mentioned above. True alluvium is only found in the flood plains of the seasonal rivers draining the rift escarpment, and there is little of this on the Station. It is typified by the presence of *Acacia albida* growing as large trees, and nearer the lake by the presence of *Hyphenae crinata* and other palms. Grass growth is large wherever absence of cover permits its development, the dominant species being *Hyparrhenia* and *Brachiaria* spp., with *Pennisetum purpureum* and *Panicum maximum* on wetter areas and particularly on the alluvium along stream banks.

The soils of the Station can be roughly classified into two series. One a reddish-brown soil on areas with good natural drainage, the other a black soil which occurs where drainage is not so good. An extensive study has been made at Rothamsted of large samples from the two series, and it appears that the general mechanical composition of the two soils is similar, and that the black coloration is due to some peculiar difference in the state of the iron compounds. The black soils show calcium accumulation in the form of nodular concretions which are lacking in the reddish-brown soils, the latter being somewhat more acid. The contrast between the two soils becomes more evident as one moves towards or away from the foot-hills, the red soils predominating and becoming redder towards the hills, and the black soils predominating on lower levels nearer to the lake.

The average rainfall for the past 17 years is 33 inches, nearly the whole of which falls in the four months from December to March. Within this period distribution is normally good, and heavy falls of over three inches per day occur only once or twice each season. Variation in the total rainfall has not been large, ranging from 27 to 36 inches, with the exception of one year when the total reached 46 inches. The distribution is important in determining high or low yields, but there is no known record of shortage of rain causing a complete crop failure. The mean maximum temperature in December at the beginning of the planting season is about 90° F. falling to 85° F. in May when the rains are over. During the same period the mean minima fall from 70° F. to 60° F. Extremes recorded to date are 101° F. maximum in November and 42° F. minimum in July.

The Station lands have a very mild slope and it has been possible to make all the fields rectangular and standardize their dimensions, which is a great advantage in experimental work. Erosion has been satisfactorily controlled by ridge cultivation and by a few shallow drains to prevent surface wash. In fact the problem on quite a large area of the heavier lands is to provide surface drainage. In a few places the general slope of about 1 in 150 is exceeded and contour bunds have been made and contour ridge planting has been adopted. The first fields opened still give as good yields as they did 17 years ago, which may be regarded as proof of the general efficacy of these mild anti-erosion measures for this particular site.

The lake shore plain lies in a tsetse fly belt and no animal-drawn cultivation has been possible except for a brief, and abortive, experiment in keeping work oxen free from trypanosomiasis by regular injections. No tractor-drawn implements have yet been used and the whole of the cultivation to date has been by hand, except for a little ploughing in the two years with the oxen. In fact it may be said that the cultivation practices on the Station are no more than could be done by an energetic African peasant.

In the account which follows all results quoted are based on statistical experiments.

Cultivation Practices

The main experiment, begun in 1938–39, was a factorial one comparing ridge and flat cultivation, early and late preparation of fields, and three levels of digging. This experiment was carried out on a black soil field in good heart for four consecutive years through the normal rotation, and similarly for three years on a brown soil field which had been cultivated by Africans and was in a low state of fertility. Results are therefore available for seven occasions. The fields used formed part of the main Station rotational plan and were cropped in cotton, groundnuts, cotton and maize, in that order. There were also several later experiments concerned with digging only, and others on the frequency and timing of post-planting cultivations on cotton. Where ridge is mentioned in this account, a low ridge some nine inches in height and 18 inches wide at the base is understood. Such a ridge settles during the season and is seldom more than six inches in height at the end of the rains.

Ridge and flat cultivation.—Three of the seven occasions were cotton crops, and in each case there was a significant increase in yield from the ridged plots. Out of two maize crops and two groundnut crops, one of each gave a higher yield from the ridged plots, once with maize there was a lower yield, and there was no difference on the other occasion with groundnuts. The yields of the ridged plots were 15–20 per cent higher than the flat plots. The germination was higher on the ridged plots; but when the yields were corrected for final stand at harvest there was still a significant advantage for the ridged plots, showing that the advantage was not due to the greater number of plants. Six weeks after planting samples taken from the cotton crop showed that the ridged plots gave plants with a greater average weight and a higher moisture content, but no difference in height. Fourteen weeks after planting the plants from the ridged plots averaged 5 cm. taller than plants from the flat plots.

Ridge planting is justified for no other reason than erosion control, and is doubly worth while as higher yields are obtained. It is suggested that the reason for the advantage is that nitrogen is not leached away so quickly from a ridge, as most of the rain will sink into the ground in the furrow. There is no direct evidence of this but the higher moisture content of the young plants is suggestive.

Time of preparation of fields.—The local African cultivator usually delays the cleaning up and preparation of old fields until the very end of the dry season, and seldom completes the work until after the rains have begun. Although it is known that in this area the highest yields are obtained from planting as soon as possible after the rains begin, traditional African methods are often sound and it was thought worth while to include this factor in the main cultivation experiment. The usual reason advanced for this habit of late preparation is that it entails less work; a field cleaned early may grow a second crop of weeds and tree root-suckers, and after rain has fallen the soil is easier to work, though few do more than burn weeds and trash in heaps. One possible reason for late clearing might be that bare fields are exposed to the very hot sun of the latter part of the dry season, and the humus content of the surface layers might be destroyed. The amount of ground-cover on the "late" plots, and the time of "early" preparation varied with the previous crop. On land emerging from rest there was dense cover, and preparation of "early" plots (digging and ridging as needed for the different treatments) was completed by the first half of May. After

a cotton crop the cover was of medium intensity and preparation was completed in July. After groundnuts there was practically no cover and preparation was completed in April. As maize was the last crop in each field there was no trial of the effect of maize trash cover. The "late" plots were left undisturbed till the latest date by which the preparation could be completed before the rains, usually about the middle of November. In all cases the trash from the previous crop was burnt on the plots in random heaps and the ash incorporated with the soil.

The results from all experiments showed a small but regular increase in yield from the "early" plots. The increase was usually less than 10 per cent and was most marked in the case of the maize crops following a cotton crop. There was no difference between the treatments in germination, weight or height of the cotton plants. It was concluded, again without direct evidence, that the slight advantage for "early" cleaning was due to greater accumulation of nitrates in the soil. The advantage was slight, and fields can be prepared at whatever time best suits the available labour, so long as preparation is completed before the rains start.

Digging.—In the main experiment there were three levels of digging, full digging over the whole area, strip digging about ten inches wide along the planting row, and no digging at all. The digging with a native-type hoe averaged about four inches in depth. No yield differences were found until the last year of cultivation in each field, which in both cases was a maize crop. In the black soil field with a very fair mean yield of 2,500 lb. grain per acre, the full digging gave a 15 per cent increase over no digging. In the worn out soil of the brown soil field with the very low average yield of 700 lb. per acre the increase was as much as 40 per cent for the full digging. The strip digging gave an intermediate yield which was not significantly better than no digging.

There were five subsequent experiments concerned with digging. Cotton was planted with three treatments, no digging, normal digging to one hoe depth, and deep digging by trenching. The results were highly significant, no digging and normal digging giving increased yields of 19 per cent and 13 per cent over deep digging. The residual effect was tested the following year with maize, and the order of yield was the opposite of that with cotton. There was a progressive increase in yield from no digging, normal digging to deep digging, and the difference only just fell short of significance. Three more experiments with maize and one with groundnuts failed to show any differences.

Maize, therefore, was the only crop which showed any positive response to digging, but the size of the increase was not large enough to pay for the cost of the work involved. From the native point of view increases in yield of the order found can be obtained with less effort by hoeing a slightly larger garden. It was concluded that digging of the land before planting was not necessary except for the first crop after a resting period; it must be done then to provide a good seed-bed. In all subsequent crops an adequate seed-bed is provided by making up the planting ridges. These conclusions would have to be modified if there was any real pressure on the land.

Early cleaning of cotton.—It does not take a profound knowledge of agriculture to realize that young cotton will not thrive when competing with a thick growth of weeds as big as, or bigger than, the cotton plants themselves. Nevertheless every year a large number of cotton gardens can be found with etiolated cotton plants drowned in a sea of weeds. This lack of attention is partly due to lack of interest in the cotton crop, and partly to preoccupation with food crops. But there are some Africans who maintain that the practice is advantageous, the cotton plant being made to grown tall and then quickly making fruiting branches when the grass is removed. The first contention is true, the second is not. Although the results of this experiment were a foregone conclusion, it was thought worth while to find out just how much the crop is decreased by late cleaning. The figures are so striking that they are quoted in full. One series of plots was cleaned before thinning, and another at the same time as thinning six weeks after planting. The plots were then divided and half had one and half two subsequent cleanings. The yields are expressed as percentages of the normal station practice.

	One cleaning after thinning	Two cleanings after thinning	Mean
	Per cent	*Per cent*	*Per cent*
Cleaned before thinning ..	84	100	92
Cleaned at thinning ..	26	40	33
Mean	55	70	—

A large percentage of the cotton gardens in the central areas of Nyasaland are not cleaned till thinning, and for many this is the only cultivation given. These figures show that the yield is only a quarter to a half of what it might be. The aggregate loss of crop, for want of a few days' work in the early stages of the plants' life, must be very large.

FOOD CROPS

Maize spacing.—Different varieties of maize have been tried over a number of years. All yellow varieties have been discarded, partly for low yield and partly because the labourers prefer to eat a white maize. Potchefstroom Pearl was grown for some years and was eventually replaced with a selection from the local mixture grown in the vicinity of the Station. This is a hard white type and, though it yielded slightly less than Potchefstroom Pearl, has much better keeping qualities, and so is to be preferred. Four spacing experiments were made on this local selection and all led to the same general conclusions. A large number of spacings and numbers of plants per hole were tried, nearly all of them with a fixed inter-row distance of three feet. It was found that two and three feet inter-row spacing was better than four or five feet, no matter how many plants per hole were left. The three feet spacing was slightly better than two feet; two plants per hole gave the maximum yield for both two and three feet spacing, one plant per hole being a good deal worse and three plants slightly lower in yield. All maize on the Station is now planted three feet by three feet, which is rather wider than is often thought to give maximum yields; less labour per acre is required when planting at three feet than at two feet. Three seeds per hole are planted and no thinning or supplying is subsequently attempted. This is a labour saving method which gives very satisfactory yields.

Groundnuts.—These are an important crop on the lake shore as they are the only leguminous food crop which can be relied on to give a good yield. A large number of varieties have been tried, both bunch and runner types. There is some variation in yield, the best averaging rather more than 1,000 lb. of shelled nuts to the acre and the worst about 800 lb. Apart from yield considerations it is important to choose a variety which is easy to harvest. The cost of growing a short ton, excluding all overhead charges, has been about £4-10-0. Rather more than half of this total represents the cost of stripping the nuts from the plant and shelling with hand labour. With a small seeded runner type from Senegal this part of the cost is at least doubled. Two types have been retained for bulk plantings, an early bunch variety from Gambia and a semi-bunch variety, Mwitunde, imported from Tanganyika. The latter matures a little later and so labour requirements are more evenly spread out during the harvesting period. It is well known that for high yields and control of Rosette disease it is essential to plant early and to space close together. The standard spacing adopted is to plant in two lines on either side of ridges spaced three feet apart; the inter-row distance on either side of the ridge is one foot. This spacing was tried against ridges one foot six inches apart with seed planted one foot apart on top of the ridge, giving the same plant population but a more even spacing; and also with one foot six inch ridges with a double row one foot apart, giving double the standard plant density. There was no advantage in the closer ridges with the same population, but when the plant density was doubled there was an increase of 210 lb. per acre in a year with the exceptionally high average yield of 1,720 lb. shelled nuts to the acre. In a year of more normal yields it is unlikely that the difference would be so great; and as the closer spacing requires about 40 lb. more seed to the acre and much more work in preparation, planting and harvesting, it is not justified. It is an advantage to sow two seeds per hole; if unshelled nuts are planted the germination is slightly delayed and is not quite so good, but the final yield is not affected. An experiment was tried with after-planting cultivation contrasting clean weeding with hand pulling of the largest weeds only, and really dirty cultivation with no weeding. The last treatment led to a decrease in yields, but there was no difference between the first two. The time of harvest is important with an early maturing bunch variety which may sprout in the ground; the optimum time will depend to a certain extent on the season and the amount of moisture in the ground at harvest time. In one experiment with Gambia bunch the highest yield was obtained 105 days after planting; a week later the yield had dropped six per cent; a week sooner or two weeks later it had fallen off by 12 per cent; and three weeks later the loss was 15 per cent.

Another point of interest with groundnuts is that if two crops are planted in consecutive years, the yield of the second crop is reduced. This was first noticed on a European estate

where large areas of groundnuts were being planted by tenant farmers. The first year yields were good, but they fell off greatly the second year. This reduction of yield might have been due to a variety of causes, but no satisfactory explanation could be advanced until a number of the tenants said that they had always found a second crop to be poor; they had not mentioned this before planting because they assumed that Europeans knew better. About the same time a large reduction in the yield of groundnuts was found when one crop succeeded another after one intervening crop. The yields are taken from a rotation experiment and are given in the table below:—

Rotation 1

1st year.—Cotton: 160 lb. lint.

2nd year.—Cotton: 226 lb. lint.

3rd year.—Maize.

4th year.—Groundnuts: 737 lb. nuts.

Rotation 2

1st year.—Cotton: 156 lb. lint.

2nd year.—Groundnuts: 776 lb. nuts.

3rd year.—Sorghum.

4th year.—Groundnuts: 374 lb. nuts.

It will be noticed that though in the first year the yield of cotton from the two sets of plots was identical, in the fourth the yield was reduced to half when groundnuts succeeded groundnuts. As no reason for this result could be found a further experiment was laid down. In the final test year of this experiment groundnuts planted in two consecutive years were contrasted with groundnuts with one, two and three other crops intervening. Different intervening crops were tested in the various treatments. The yields are given in the table below:—

	lb. Shelled nuts per acre
Groundnuts following groundnuts	814
With one intervening crop ..	915
Mean of plots with two intervening crops	1,054
Mean of plots with three intervening crops	1,035
Significant difference	218

There was no difference between plots in the incidence of Rosette or wilt disease, the amount of these diseases being negligible in all cases. It is not usual to plant groundnuts in consecutive years as it has been found that maize gives an increased yield when following groundnuts. There should be at least two intervening years before the crop is planted again, under the conditions which obtain at the Cotton Station.

Maintenance of Fertility

When the Cotton Station was first opened the rotation adopted was three years crop followed by two years rest under Pigeon Pea. Maize was always the last crop in the rotation and the Pigeon Pea was sown from four to six weeks after planting the maize. There were signs that this amount of rest would not maintain fertility indefinitely, but there were difficulties in the way of extending the period under Pigeon Pea. After the first year termites caused a big loss in the Pigeon Pea, and by the third year there were very few plants left. Also a wilt disease attacked the plants in patches, leaving a very poor stand. About that time Martin drew attention to the beneficial effect of grass on soil structure in Uganda. Elephant grass is not found on the main lake shore plain, but only alongside the streams which run down from the hills during the rainy season. Every year the dried tops are burnt by bush fires, but the grass is not killed and planting material can always be obtained at the beginning of the wet season, and it has been found that these plantings grow well under field conditions.

A rotation experiment was planned in 1936 to test the suitability of using Elephant grass to restore fertility. Various rotations were employed and the main comparisons were between no rest, one year's rest with Pigeon Pea, two years' rest under either Pigeon Pea or Elephant grass, and three years' resent under Elephant grass. Cotton was used in the first test year and maize for the second year. With the cotton crop the last three treatments were all equal and all better than one year or no rest. With the succeeding maize crop the results were rather different. Three years' rest was better than two years, and Elephant grass was better than Pigeon Pea. It was therefore concluded that three years' rest under Elephant grass was the minimum required and further experiments are in progress to find out if four or five years give still better results.

It was thought that the lack of a leguminous crop in the resting period might slow up the restoration of fertility. If very worn out land is abandoned to bush there is often a very heavy, almost dominant, growth of

Buffalo bean (*Stizolobium* spp.) which becomes less common in later years. It has also been noticed that Elephant grass planted on badly run down soil grows less luxuriantly when planted alone than when mixed with Pigeon Pea. Accordingly an experiment was planned contrasting Elephant grass alone and mixed with velvet bean. No difference was found in yield when cotton was planted subsequently. The point cannot be said to have been proved as it was impossible to prevent the growth of Buffalo bean among the Elephant grass. The seeds of this plant must be capable of lying dormant for at least five years, as they grow up freely even after five years clean cropping.

The planting and subsequent clearing of Elephant grass involves an amount of labour which does not appeal to the African cultivator, so trials are going on to try to find a simpler method of resting the land. Various rest crops have been tried including Pigeon Pea, allowed to degenerate into weeds, chance weeds, and the local long term sorghum treated as a perennial. So far the results have been inconclusive as no differences have been demonstrated.

Experiments have been made on different spacings and times of planting of the Elephant grass, and results show that a wide range of both seem to give equally good results. Spacings have been tried from three feet by three feet up to eight feet by three feet, and the resulting cover has always been excellent. This is a good deal wider than is reported as being necessary in Uganda to establish a good cover. The local variety of Elephant grass is stoloniferous, and after the first year, when growth in Nyasaland appears to be slower than in Uganda, the spread is rapid and all other grasses are largely suppressed. The planting material used is main stems cut up into lengths of about two feet six inches, pieces bearing roots being preferred. These have been planted from January to early March, not far from the end of the rains, and in all cases a good stand has been obtained. For the time being the standard Station practice is to plant Pigeon Pea among the maize about the middle of January, when the maize is four to six weeks old. Elephant grass is planted later whenever labour is available, generally during a wet spell when hoeing is impossible. In the first year the Elephant grass makes little growth and the Pigeon Pea gives a crop about September. During the second year the Elephant grass makes rapid growth and a second crop can be taken from the Pigeon Pea if wanted. After that a good deal of the Pigeon Pea dies out with termite attack and is more or less swamped by the vigorous growth of the Elephant grass. The year before the land is to be cleared the grass is fired at the end of the dry season, and a fierce fire and a clean burn is the normal result. If this burning is omitted clearing is more troublesome the following year. A strong re-growth is made during the rains and this is cut down in March or April, burnt as soon as dry and the land then dug. Some roots continue to grow during the dry season and these are dug up at intervals. The grass can be burnt at the end of the dry season and the land immediately prepared for planting. But if this is done it is impossible to kill more than a percentage of the roots and a lot of labour is necessary in frequent cleanings of the subsequent crop.

Mixed Cropping

Mixed or inter-cropping has been tried at various times without success. The very short growing season necessitates the planting of all crops at the break of the rains to get maximum yields, and young plants growing together compete strongly for the available nitrogen. The common haricot bean, which grows well among maize at higher elevations, does not thrive in the hotter climate of the lake shore. If groundnuts are planted among maize the yield of the latter is not affected, but with a good growth of maize the yield from the groundnuts is so small as to be hardly worth the bother of planting. Similarly groundnuts give a very low yield if planted among rows of cotton, and cleaning the fields is more difficult. If cotton and maize are planted on alternate rows the cotton is so suppressed that the yield is negligible. There is little doubt that for maximum returns crops must be planted in pure stand in this area. Further experiments are being made with planting cotton among wide spaced maize, not with the idea of increasing cash returns per acre, but to encourage new people to plant cotton because they will obtain a food supply at the same time as they are earning some cash.

Rotations and Fertilizers

There has only been one experiment with different rotations; the only positive result was that maize yields more when planted after groundnuts than after cotton. In one year the

increase was 40 per cent and another year only 10 per cent. The rotation finally adopted is cotton, maize, cotton, groundnuts and maize, the last being inter-planted with rest crops. This rotation is not designed to be suitable for peasant cultivators, but has been adapted to meet the needs of the Station; the chief of these are an adequate acreage of cotton for experimental purposes and the provision of food crops for the labour force, and at the same time the fertility of the soil must be maintained and if possible improved.

This rotation of five years cropping followed by four years rest under a mixture of Elephant grass and Pigeon Pea, is one which should maintain a good soil structure indefinitely. It also appears that there are enough plant nutrients in the soil to give continuous yields. Experiments on the use of compost have shown that yield increases are only obtained with uneconomically large dressings. Artificial fertilizers, owing to their high cost and the low value of the crops grown on the Station, have not been considered important. One experiment with artificials was made but no increases in cotton yield were found, nor were there any residual effects on maize the following year. New fertilizer experiments are being planned, and only the future can prove if the above cropping scheme will maintain yields at their present level. It is hoped, however, that neither artificials nor compost will be needed for a long time to come.

IODINATED PROTEINS AND MILK PRODUCTION

Milk secretion has long been known to be initiated and maintained by a number of internal secretions or hormones, but it has been in recent years only that the possibility of using endocrine preparations to increase the milk yield of dairy cows has been realized. Before then any hormonal treatment of large animals was prohibitive in cost, for the amounts of expensive glandular extracts needed were immense, while a further objection was that administration involved injection—an operation not to be entrusted to many farmers.

The discovery that the iodination of casein and other proteins rich in the amino acid tyrosine resulted in products—iodinated proteins—from which thyroxine could be isolated in comparatively large quantities, meant that as far as the thyroid gland was concerned a cheap source of the hormone was available, and at the same time it was known that the thyroid hormone was physiologically active when given orally. Under the auspices of the Agricultural Research Council, work on these iodinated proteins was commenced in 1941, and it was shown that when they were fed to dairy cows, milk yield, and more especially fat yield, increased by up to 50 or 60 per cent. The thyroid hormone is a general accelerator of body processes and, parallel to these increases in milk and fat yield, increases occurred in the metabolic rate of the cow. Thus the pulse of the cow, normally 60–70 beats per minute, increased to 85–90, her respiratory rate was augmented, her body temperature rose slightly, and she lost weight. All these symptoms of an increased metabolic rate increased in intensity as the dosage was increased, and when large doses were given it was obvious that a considerable strain was being imposed on the cow. For this reason doses of 20 grammes per day, sufficient to produce an increase of only 20 per cent in milk yield, were thought optimal. The loss of body weight could then be prevented by adjustment of the cow's ration to offset the increase in her basal metabolism. At the beginning of the cow's lactation, when her milk yield is maximal, iodinated casein has but little effect, and the largest increase is obtained when she is in the middle and later part of her eleven-month lactation. Large-scale experiments on commercial dairy farms have been carried out using the information obtained in the smaller experiments. Five hundred cows were fed iodinated casein incorporated in cattle cubes, while five hundred cows on the same farms acted as controls. In a period of six weeks the milk yields were increased by 23 per cent, and over nine thousand gallons more milk was produced by iodinated casein treated cows. No adverse effects were noted.

It might be wondered why iodinated casein is not being used to increase the milk yield of Great Britain's dairy cows at the present time. The reason is that the possibility of a reduction in the longevity of the cow as a result of intermittent dosage with iodinated casein, though perhaps a remote possibility, must be thoroughly investigated before iodinated casein can be used as a general measure for increasing milk yields. This aspect is now being investigated in long-term experiments with large numbers of dairy cows, in which the productive life-span of the cows is being measured.

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A DESCRIPTION OF AN EASILY MADE HARD PRESSED CHEESE

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In the course of instruction on cheesemaking at the Egerton School of Agriculture it was found that no English cheese met the first requirements of the Kenya settler—ease and rapidity of make, and full flavour. The cheese which probably most nearly met these requirements was a Lancashire one and it was from this starting point that the following method was evolved; certain family resemblances are obvious. However, the resultant cheese approximates very closely indeed to the accepted characteristics of a farmhouse Cheddar, despite the simplifications made in its manufacture.

All the usual precautions with regard to milk for cheese-making should be observed, namely, health of cow, period of lactation, e.g. not until 10 days after calving nor after the 8th month, cooling the evening's milk and the gamut of clean milk production. It is impossible to produce first grade cheese from inferior milk.

Mix evening and morning milk (if the cream of the former fails to mix back readily pour off, warm to 100°F. and return to its milk). The mixed milk is held at 73–78°F. while ripening. The milk at renneting should be as ripe as for Cheddar (say, 0.2 per cent on the acidimeter using N/9 soda), this generally requires about 1½ to 2 hours. In the farmhouse a little buttermilk from some clean acid cream may be added in lieu of a starter immediately after mixing morning and evening milk. If preferred, all morning milk may be used but the ripening period will then be found to be longer, probably 2 hours on an average.

The addition of a soluble calcium salt enables less rennet to be used, and this will improve the cheese by allowing normal ripening. The ideal method of adding the calcium is from a stock solution of calcium chloride. Either 5 oz. of anhydrous calcium chloride dissolved in enough water to make half a pint of solution (of this stock solution 1 dessertspoon or ¼ fluid ounce should be used to each 3 gallons of milk) or 5 oz. of hydrated calcium chloride dissolved in enough water to make ½ pint of solution. (Of this solution 2 dessertspoonfuls or ½ fluid ounce should be used to 3 gallons of milk). Alternatively, two tablets of Glaxo Osteocalcium to 3 gallons of milk have been used on occasion with success; all trace of peppermint flavour being lost during manufacture. Such tablets should be crushed and dissolved in a little warm water. The calcium salt is added when morning and evening milk are mixed.

Hansen's cheese rennet tablets may be obtained locally and it will be found necessary to use one tablet to 12–14 gallons of milk. The required amount of the tablet should be crushed and dissolved in cold water.

Renneting and Scalding.—Rennet is added at 86°F. in the usual way, deep stirring for 3 minutes, top stirring to keep down the cream until bubbles persist. The junket is generally fit to cut in 60–70 minutes, rarely before. The methods of judging when a curd is fit to cut are either (1) to attempt to draw away the curd from the side of the vat with the back of the hand, if the curd is ready it will leave the side of the vat cleanly or (2) to thrust the first finger of the hand straight down into the curd and then lifting this finger out so as to break the surface horizontally. If, as this finger nears the surface, the curd breaks cleanly on the finger then the curd is fit to cut. It is cut with an American curd knife with blades of ⅜ in. apart preferably, both across the vat and along the vat, the knife being held vertically, then with a horizontal knife so as to produce small cubes. In the farmhouse a carving knife is used and horizontal cutting is improvized. These cubes are further cut by slashing with a vertical knife. The curd particles are particularly delicate at this time and stirring must be very careful and slow but complete to prevent the coalescence of the particles. After ten minutes the scald is begun, that is to say, the temperature around the container of the curd and whey—i.e. the jacket, is slowly raised to 96°F. during 20 to 30 minutes. This is effected either by increasing the temperature or by baling out some of this whey, heating it to 120°F. and returning it to the main bulk; by repeating this latter procedure the temperature may easily be increased the necessary amount. The curd is pitched 30–40 minutes after cutting, that is by ceasing to stir, the particles are allowed to settle out on the bottom of the vat.

There the curd is allowed to remain undisturbed for 30 minutes during which time the acidity increases so that 0.19 per cent at the end is an average reading. By this time the mass will have gone together and will rather resemble "brains".

Cheddaring.—The whey is then drawn in large scale production or, in the farmhouse, is poured off through a piece of butter muslin into which the curd is slid. In small scale making this cloth is secured "Stilton" fashion, that is to say, three corners are held in one hand and the fourth wound round these so that the tightness of the bundle can be varied at will be merely taking an extra turn of the odd corner. This bundle is left to drain freely for 10 minutes, then it is opened up and the contents cut into pieces 1¼ in. by 1¼ in. and these pieces stirred. The cloth is resecured and a weight placed on the mass. For curd from 10 gallons of milk a weight of 10 lb. is sufficient. Larger amounts require greater weights. After a further 10 to 15 minutes the cloth is opened up when the fingers of curd will be found to have gone together into a solid mass which is once again cut and stirred as before. When the cloth has been resecured, the weight is increased to 14 to 15 lb. for 10 gallons of milk and the whole is left for half an hour. Then it is cut a third time, resecured and the weight increased to 20 lb. for 10 gallons of milk. The fourth cut, which will generally be found sufficient, is made after a further 45–60 minutes.

Milling.—An hour later the curd is fit to mill and salt (acidity should then be 0.7–0.82 per cent). Milling is carried out with a peg toothmill or, in small scale production, by tearing the curd into particles the size of walnuts. Salt is added at the rate of 1 oz. to 2½ lb. curd. The salt is thoroughly stirred and the curd then left for the night so that any whey which may exude runs clear of the curd. This prevents sliminess of the curd particles. Considerable latitude may be taken with the times and treatment after the second cut without seriously harming the cheese.

Next day two plans are open—

(*a*) to make a second cheese, mix the two curds and to put them to press that night;

(*b*) put the first curd to press alone.

Pressing.—The curd particles are packed into a mould lined with a coarse cloth. A metal cooking pot with holes punched in the bottom and sides or even a jam tin (7 lb.) similarly treated from which the lid has been carefully removed will be found suitable moulds for small scale manufacture. The cloth is pulled up all round the curd so as to remove any pockets and one corner of the cloth is stretched smoothly over the follower, a disc of wood fitting loosely into the mould. The cheese is put to press for 6–8 hours under light pressure. In small scale production one hundredweight will probably suffice. Over-pressing is characterized by the exudation of fat. After six hours it is generally safe to increase the pressure, say, to two hundredweight for small scale production.

The second day the cheese is removed, turned, replaced in the mould and put back to press.

Next day the cheese is removed from the mould, trimmed by cutting off any projecting corners and bandaged with two round caps which fit over the top and bottom respectively and a third piece of cloth stretched round the sides of the cylindrical cheese and sewn tightly in place. The cheese is then returned to press for an hour or so to improve its shape, then removed and taken to the ripening room.

Ripening.—It has rightly been said that when a cheese goes to the ripening room it is only half made. After two days the surface will have dried and should then be rubbed with unsalted lard to seal the rind, prevent loss of moisture and improve its appearance. Thereafter the cheese should be turned each day until it is consumed.

The temperature of the ripening room should be, ideally, between 52° and 58°F.—at higher temperatures ripening proceeds faster but is liable to produce unpleasant flavours. The humidity of the ripening room must be kept high so as to reduce loss in weight of cheese by drying and consequent cracking. If ripening is carried out at 58°F. this cheese will be fit to cut in the following times:—

8–10 weeks for 8–12 lb. cheese.
10–12 weeks for 12–20 lb. cheese.
12–14 weeks for 20–50 lb. cheese.

Summary of the Process of Manufacture

Evening milk cooled to at least 65°F.
Evening milk next morning: 0.2 per cent acidity.
Mixed milk before renneting: 0.2–0.23 per cent.
Whey after cutting: 0.15 per cent.
Whey at pitching: 0.18 per cent.
Whey from curd at first cut: 0.2 per cent.
At milling: 0.65–0.8 per cent.
From mixing milk to renneting: 1½–2 hours.
Renneting to cutting: 60–70 minutes.
Cutting to starting scald: 10 minutes.
Cutting to pitching: 30–40 minutes.
Temperature of scald: 95–97°F.
Time pitched: 25–35 minutes.
Renneting to milling: 5 hours.

LIVE STOCK IMPROVEMENT IN THE BUGANDA PROVINCE OF UGANDA

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Introduction

In nearly all parts of Uganda stock are kept by African farmers who are also cultivators. We have few areas where ranching is a major means of livelihood, and even in these areas most of the stockowners also grow crops for food. Few of our farmers, however, are true mixed farmers in that maximum use is seldom made of manure for fertilizing crops, nor are surplus crops generally used for feeding live stock. A few tribes use cattle for draught purposes, and in areas where human and animal populations are dense the resting grass fallow is frequently grazed. It is true that occasionally surplus crops are used for stock-feed, but the vast majority of the cattle of the country live on unimproved natural grass-land.

Experimental work in Uganda tends to confirm evidence obtained in other countries in recent years that both sides have everything to gain by closer interlocking of stock farming and arable cultivation. The precise method by which this interlocking can best be obtained varies from place to place. The extent to which food supplements for cattle can be justified depends upon the prices obtaining for milk and beef. The extent to which manure can best be utilized as dropped manure on the resting ley, or as farm yard manure or compost, depends upon the value of the crops obtained from arable land and upon ease of transport and other factors.

This article describes work which has been carried out in the past three or four years in an area of Buganda selected as a Live Stock Improvement Area.

Machinery of the Improvement Scheme

Work in the Improvement Area was started by the Veterinary Department, who paid most attention in the early stages to selection of improved bulls and treatment of disease. It was soon found that use of improved breeding stock was a waste of time without better feeding. Better feeding in the long run could only be obtained by better cultivation methods and by better management of grazing. It became clear therefore that maximum benefits could only be attained if the agricultural and veterinary departments worked in the closest collaboration.

Various attempts have been made in the past to define the scope of the work of the two departments. These attempts have never led to satisfactory results, and are not likely to do so. The Director of Agriculture and the Director of Veterinary Services decided early in 1946 to attempt to solve this problem the other way round. They set up a Husbandry Committee containing officers of both departments, the function of the Committee being to advise officers of both departments working on husbandry problems. This Committee acts in an advisory capacity only. Its members are chosen as individuals for their knowledge of the problems concerned. There are no *ex-officio* members of the committee.

The programme of work for this Live Stock Improvement Scheme in Buganda, as for similar projects elsewhere, was submitted by the local veterinary and agricultural officers to the Husbandry Committee for advice and suggestions. Both departments have African staff in the area who work in close collaboration.

The progress which has been made in this area is very encouraging, and the method by which results have been obtained may be of some interest to people faced with similar problems elsewhere. Government technical departments are frequently criticized because they succeed in amassing information as to how things should be done, but are usually less successful in getting new ideas across to the people. In many cases no doubt the reason for these failures is economic; the improvements recommended may be unsound economically, or beyond the means of the African farmers. People sometimes forget that the African farmer, like his counterpart elsewhere, expects any improvement to produce a greater return without any additional expenditure of energy. In other cases, however, failures have been due to incorrect methods of getting into contact with the farmer. In many parts of Uganda new ideas must of necessity come through the chief. In the Buganda Province, however, chiefs have a full-time job collecting taxes, administering justice and other duties, and are not normally able to expound agricultural matters to their people. On the other hand many of the farmers have had a considerable amount of education.

In these circumstances it was considered advisable in the Improvement Area to rely on direct contact between the African staff of the technical departments and the more progressive African farmers.

The African farmer is afraid to act by himself, and needs some form of association where men with similar problems can meet for discussion. The live stock owners of the Improvement Area, which is at Ngogwe in Kyagwe County, have formed themselves into a Live Stock Association. The Association holds monthly meetings. It has acted on behalf of its members for purchase of cotton seed for stockfeed, purchase of wheelbarrows from government, purchase of cattle salt, etc. It made regulations when a few cases of trypanosomiasis occurred in the area recently. It makes arrangements for visits by its members to prominent stock farmers and government farms, and for the entertainment of visitors to the area. The Association also acts as a convenient means of contact between government and farmers when new suggestions are under discussion. Chiefs also are consulted when necessary, but the Live Stock Association can deal with most of the day to day details.

Stock Keeping Methods

The people of Buganda have always owned considerable numbers of stock, but supervision and herding was normally carried out by alien herdsmen. Cattle were kept under semi-ranching conditions many miles away from the owners' homes. The herdsmen received very low wages, but took most of the milk produced as payment for their work.

Cattle were in most cases kept in fairly large herds, each herd containing stock belonging to a number of different owners. Under these conditions no control of mating was possible and improvement by selection was difficult.

Cattle were kept at night in open bomas, and were grazed on communal grazing lands usually situated on poorly covered hill-sides or swamp fringes. The grazing of resting leys was not utilized; grazing control was difficult; feeding up the more productive cows was not feasible, and manure utilization was impracticable.

During the past 10 to 15 years there has been a very steep rise in the value of live stock and live stock products in Buganda. A general increase in the wealth of the people has stimulated the demand for milk and meat to such an extent that to-day a bottle of milk costs 30–40 cents and a pound of meat 50 cents or more. About 10 years ago a few farmers in Buganda began to realize that money could be made from live stock, and that stock kept according to the traditional methods gave poor returns.

About the same time, the introduction of effective methods for control of rinderpest, attempts to achieve which had previously absorbed much of the veterinary officers' time, combined with the recruitment of assistant veterinary officers from Makerere College and a noticeable improvement in the lower ranks of African employees, allowed the department to devote more time to animal husbandry. In Buganda it was considered advisable to concentrate attention on a few selected areas. Each area is under the control of an Assistant Veterinary Officer, who is expected to know most of the stock farmers in his area individually. Propaganda has very largely been confined to the individual approach. Chiefs have been informed what is being done, and have given their advice and consent, but most has been achieved by direct contact between African employees of the department and individual stockowners, or the stock-owners' associations which have been formed in some cases. This method of approach, combined with the obvious economic benefits of the improvements advocated, are believed to be a major reason for the very considerable success achieved.

Though some improvements have been obtained throughout Buganda the biggest advances have been produced in the counties of Kyadondo and Kyagwe, which have cattle populations of approximately 13,000 and 34,000.

Improvements can best be considered under four heads:—

(i) Management.

(ii) Feeding.

(iii) Selection.

(iv) Utilization of manure.

(i) *Management.*—The main objective has been to persuade owners to take a real interest in their cattle. This in most cases has involved bringing the cattle near to the owner's home so that he can supervise them himself, and in some cases herd them himself, instead of employing alien herdsmen. In most cases this automatically causes splitting up of large communal herds into small herds belonging to one or two owners. Benefits obtained from

improved supervision have been striking. The owner sees that his calves get enough milk and many of the calves are now in very good condition. A very marked reduction in death rate from east coast fever in well managed herds has also been noted. In some villages in the Ngogwe area the death rate in 1946 was as low as 5 per cent though there is no doubt that practically all calves get the disease.

Proper management of cattle in most parts of Buganda necessitates construction of houses where cattle can rest in the middle of the day. Cattle which remain outside these houses are continuously pestered by Stomoxys flies, but smoke and darkness both act as repellants to these flies and experience has shown that they cause little trouble if the cattle are kept in darkened houses with smoky fires burning. Cattle are normally kept inside from 12 noon until 3 or 4 o'clock in the afternoon. In the Ngogwe area 350 stockowners out of a total of 490 have now built houses for their cattle, and numbers are increasing rapidly.

(ii) *Feeding.*—All evidence available in Buganda suggests that, in spite of the luxurious grass growth normally to be seen, marked improvements in milk yield and live-weight gains cannot be achieved without supplementary feeding. The main supplements now used are raw cassava, household waste such as banana peelings (cooked bananas are the staple food of the people of Buganda), maize, cut elephant grass (mainly fed to calves) and cotton seed. Some of the herds given ample supplies of these supplements are in first class condition, and milk yields from unselected Zebu cows of 10 to 12 pints per day have been recorded on a number of occasions.

Improvement of grazing has so far received less attention than feeding of supplements. Perhaps the main reason is because less is known of this subject. A certain amount of experimental work has recently been started at Government experiment stations, partly in the form of small experimental plots run by African farmers on their own land. The most hopeful lines of attack are replacement of the rather useless *Cymbopogon afronardus*, which is dominant in much of the grazing in the Ngogwe area, by a local strain of Rhodes grass, *Chloris gayana*, or by species such as *Brachiaria decumbens*, *Panicum maximum* and *Setaria sphaceleta* which come in when the *Cymbopogon* is dug out and the land subsequently heavily stocked.

A number of farmers have tried digging *Cymbopogon* out of their grazing land. The results so far achieved have been promising, and in order to obtain additional experimental evidence, a few farmers are being given fencing materials as an encouragement to carry out small trials. Similar small experiments are being carried out on farmers' land with Rhodes grass.

In addition to these small experimental plots, a grassland experimental sub-station is being opened at Ngogwe where field trials can be carried out under controlled conditions. Every endeavour is being made to get local farmers to make suggestions for the running of the sub-station, and to regard it primarily as their experimental farm.

(iii) *Selection.*—All cattle in Buganda are Zebus, Ankole Longhorn or mixtures between these two breeds. A local type is recognized, which is a mixture of the two breeds, but it is doubtful whether it is a fixed type.

Numerous attempts have been made to introduce European blood into Uganda, but none have so far met with any success, one reason being the high death rate from tick-borne diseases.

Work in South Africa and elsewhere has shown that European breeds will not thrive under tropical conditions, and this is an additional reason for concentrating work on improvement within the existing breeds, rather than by bringing in European blood. It must also be borne in mind that a 600 lb. Zebu cow producing say 200 gallons of milk with a butterfat content of 6 per cent in one lactation period is by no means an inefficient producer.

For these and other reasons selection has been confined to local cattle. One method of obtaining improvement would be to carry out selection at large government stock farms and sell the progeny to selected farmers. This method could not be used because there were, and still are, no large government stock farms, and such a farm requires at least 10 years to work up a tested herd of any real value. It is also worth noting that this is not the method used in Britain, America or other countries where very real improvements in stock have been achieved. In those countries the pedigree breeder is the source of most improvements, and it was decided that this was the most hopeful method of tackling the problem in Buganda.

A survey of the herds in the area was carried out, and a number of herds selected as the best

available. These selected herds cannot be expected to contain a fixed strain of super stock, but they are undoubtedly much better than the general average. All males in these selected herds are kept for breeding purposes; in some cases they are bought by government for issue or loan to owners who require improved bulls; in other cases they are sold direct from owner to owner. Owners are only too willing to co-operate as they get very good prices for their bull calves.

In order to avoid the danger of dissipating improved strains over a wide area an attempt is being made to concentrate selected bulls in one area. In Ngogwe gombolola* where there were 9,000 cattle in 1946, improved bulls are loaned by the Veterinary Department to owners, or groups of owners. The owner's incentive to use these bulls is partly that he appreciates that he will get better cattle by using them, and partly that he wants to become a selected herd owner himself in order that he may get high prices for his bull calves. Castration of poor type bulls in the selected area is obviously desirable. So far no great difficulty has been encountered. Owners are satisfied that bulls loaned to them are better than those which they were previously using, and are in most cases prepared to castrate the latter when advised to do so. In the course of time Ngogwe should form a pool of improved cattle for use elsewhere.

Increase of improved cattle is a very desirable objective but standards of improvement are not always so easy to define when one comes down to details. Though beef cannot be neglected, the prime objective in this area must be milk. The African stockowner usually has rather vague ideas about the relative milk yielding capacities of his cows, and these impressions have of necessity to be used in the first place. In the last year or two a few farmers at Ngogwe, and one or two elsewhere, have started a very simple form of milk recording. Charts are made out and distributed on which the total milk yield on the eighth day after calving, and subsequently at one month intervals, is recorded. Names and histories of the cows are also recorded. Much of this work has to be done by African Veterinary Assistants, but a number of the stockowners are sufficiently well educated to do their own recording after being shown how to do it. It is too early yet to say whether it will be possible to bring many farmers into this milk recording scheme.

(iv) *Utilization of Manure.*—Good land is valuable at Ngogwe because prices obtained for produce which can be put on the Kampala market such as bananas and beer, as well as for other cash crops such as coffee, cotton and maize, are high, and it is very probable that applications of dung or farm yard manure will produce an economic return. Farmers already realize the benefits to be obtained by applying manure, but in the past have been unable to do so owing to the long distances between the cattle grazing areas and the cultivated plots, and to lack of transport. The major difficulty has been removed now that most of the cattle pens have been built near to the banana gardens. The most convenient means of transport has so far been found to be the wheelbarrow. During 1946 about 30 wheelbarrows from military stocks were sold to stockfarmers in Ngogwe at cost price, and about 100 farmers have now started applying manure. The majority are applying this to their banana gardens, where the benefits have been well marked.

* A gombolola in Buganda is an administrative division comparable in size with the area administered by a Rural District Council in England. Ngogwe gombolola has a land area of about 200 square miles and a human population of about 13,000.

SWINE ERYSIPELAS IN KENYA

By S. E. Piercy, Veterinary Research Officer, Veterinary Research Laboratories, Kabete

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The purpose of this article is to draw attention to the fact that swine erysipelas, a disease hitherto unknown in Kenya, has now been identified and the causal organism *erysipelothrix rhusiopathiæ* isolated. This disease has been recognized in continental Europe for over 60 years and causes great losses in swine-raising districts where it sometimes assumes an epizootic character. It is cosmopolitan in distribution and exists in countries as widely separated as America, Asia, Japan, and Australasia. It is surprising, therefore, that so little is heard of the disease in the continent of Africa. Merchant [1] mentions its existence in North Africa, and Haig and Adelaar [2] report for the first time a single case in the Union of South Africa. It is unknown in the Sudan, Uganda and Northern Rhodesia. In Tanganyika it has been suspected on two occasions but has never been confirmed.

The presence of swine erysipelas in Kenya has been suspected for some years but it was not until 1946 that these suspicions were confirmed following the submission to the laboratory of material from pigs that had died in two different districts. These specimens were examined by the writer and by a colleague [3] in the course of routine duties, and unknown to each other at the time, and it was a peculiar coincidence that the discovery of the disease should have been made, for the first time, in the same week, by two officers working independently, particularly as it transpired that these two cases were not the precursors of large-scale outbreaks. In point of fact, only one other case has since been confirmed.

History

The material received by the writer was the heart of an 8-months old, pure-bred, Wessex Saddleback boar, bred in the Colony and purchased by the owner as a 10-weeks old weaner. It lived, thereafter, in a sty by itself and thrived until shortly before its death when it was observed to be listless, and stiff in the hind-quarters, A day or two later, a few hours after feeding normally, it was found dead. The owner performed a post-mortem and noticed an enlarged liver and pericarditis.

When the heart was examined at the laboratory swine erysipelas was immediately suspected since the valves on the right side bore cauliflower-like growths, up to a grape in size, which are characteristic of this disease. Smears were made from these vegetations and revealed the presence of tiny, thin, rod-like bacilli. These organisms were recovered in pure culture after inoculating material from the growths into laboratory media and incubating at blood heat for 24 hours. Subsequent detailed bacteriological examinations and pathogenicity tests on pigeons, rabbits, guinea-pigs and mice confirmed beyond all doubt that this was, in fact, the bacillus of swine erysipelas.

Definition

Swine erysipelas is an infectious, bacterial disease of pigs characterized by fever, unthriftiness, purple patches on the skin and lameness. It also occurs naturally in man, mice, ducks, fowls and pigeons and can be transmitted to several other species by artificial means. Cases of arthritis in very young lambs have also been shown to be caused by the bacillus of swine erysipelas [4].

Etiology

The causal organism is a minute bacillus which lives in the soil where it can remain alive for considerable periods. It has also been found in the tissues of healthy pigs which may thus act as carriers of the disease. It possesses considerable resistence to adverse conditions and can live for several months in putrefying meat and decomposing carcasses. Pigs become infected by eating material contaminated with the organism and occasionally through skin wounds. The incubation period is about 5 days and the disease is directly contagious by means of the excretions.

Symptoms

Swine erysipelas is a disease of young pigs, the most susceptible period being from 3 to 9 months old. It may be acute, mild or chronic.

The acute form is characterized by a high temperature, inappetence, dullness and constipation. Death may occur within 24 hours or may be delayed for several days, in which latter case characteristic square or diamond-shaped, urticarial, raised, purplish patches appear on the skin of the chest, neck, back and thighs. Lameness and swollen, painful joints may be observed.

The mild form is similar in the early stages but death rarely occurs and symptoms disappear in 5 to 6 days time.

The chronic form is not so much a separate entity as a sequel to the acute or mild forms. There may be apparent recovery but a month or two later the pigs show signs of heart disease and almost invariably die. Chronic swine erysipelas is characterized by general unthriftiness and debility, sluggishness, reluctance to rise, laboured breathing and purple discolorations of the skin.

Post-Mortem Lesions

In acute cases the most striking lesions are reddish-purple patches on the skin, and hæmorrhages on the inner and outer surfaces of the heart muscle and on the outer surfaces of the kidneys, stomach and intestines. Inflammation may be present in the small intestine and not infrequently a yellow deposit is found on the mucous membranes of the colon and cæcum. The lymphatic glands are swollen, congested and hæmorrhagic.

In chronic cases skin discolorations are not so marked, and hæmorrhages on the internal organs may be absent or uncommon. The lungs may be œdematous and there is usually evidence of chronic enteritis. The most striking lesions, however, are cauliflower-like growths on the valves of the heart. These vary in size from a pea to a walnut and are friable in nature.

Diagnosis

Since acute swine erysipelas may quite easily be confused with swine fever, careful attention should be paid to post-mortem appearances. In particular, it should be noted whether the mucosa of the intestines is ulcerated or merely inflamed, since an ulcerative condition is not found in swine erysipelas but is common in swine fever. Swine fever in East Africa is also characterized by very dark, almost black, congested lymph glands, particularly those at the base of the liver. Chronic swine erysipelas is easily recognized when cauliflower-like growths occur on the valves of the heart. When these are absent, a history of lameness and painful joints should be sufficient to warrant the submission of suitable material to the laboratory.

Laboratory Diagnosis

Steps should always be taken to verify a diagnosis of swine erysipelas by the submission of suitable material to the laboratory. The causal organism is easily identified and recovered, since it is resistant to putrefactive processes. The ideal proceedure from the point of view of the laboratory diagnostician is to submit the whole carcass, suitably wrapped up to prevent spreading the disease, but it must be admitted that this might prove to be a dangerous practice. It is wiser, therefore, to send the heart and pieces of liver, spleen and kidney, without preservative. In addition, whenever possible, blood mixed in equal proportions with citrate solution, obtainable from the laboratory on request, should be sent. In chronic cases, when there is a history of lameness, and in the absence of heart lesions, the limb in which lameness has been observed should be submitted since it may be possible to isolate the organism from the bone-marrow or affected joints.

Treatment and Prevention

When an outbreak of swine erysipelas is diagnosed, prompt measures should be taken to prevent the spread of the disease by isolating affected pigs, burning or burying carcasses, and thorough disinfection of infected premises and utensils. Under the Diseases of Animals Ordinance infected piggeries are placed into quarantine so as to curtail the movement of pigs and thus minimize the danger of the disease spreading. When hyper-immune serum is available all affected and in-contact pigs should be inoculated without delay.

In Great Britain and many other European countries preventive immunization is practised by infecting pigs with an attenuated strain of the organism and controlling the reaction by simultaneous injections of serum, in exactly the same way as the majority of animals in East Africa were immunized against rinderpest before the advent of attenuated goat virus. Ten days later the pigs receive an injection of virulent organisms in order to produce a solid immunity. Pigs which recover from a natural attack of the disease are immune.

Discussion

When the cases of swine erysipelas reported in this article were confirmed, it was feared that they might prove to be the precursors of large-scale outbreaks. Fortunately, however, only three cases have been confirmed. They occurred in widely separated parts of the Colony and it is of interest to note that only one pig died on each occasion. Several attempts to infect pigs with the isolated organisms have

been made at the laboratory without success, and although it must be admitted that other workers have found that it is extremely difficult to infect pigs by artificial means, it would seem that swine erysipelas in Kenya is of a very mild nature and has not, so far, assumed an epidemic character. Nevertheless, the possibility of the organism gaining an enhanced virulence cannot be overlooked and work is now proceeding to produce an efficient hyper-immune serum by the regular inoculation of horses with increasing doses of virulent culture.

Inquiries have failed to reveal the origin of the three known outbreaks and the only way that is apparent in which the disease might have gained entry to the Colony is through pigs imported from countries where swine erysipelas is endemic. It also seems likely that the disease has, in fact, existed for some time but that its mild character has precluded correct diagnosis. In 1940 a report was received from a bacon factory of a death of a young pig bearing the classical diamond skin lesions of swine erysipelas, and in 1943, two laboratory workers became infected with skin erysipeloid after investigating deaths amongst domesticated pigeons. Farmers and veterinarians are familiar with various pig ailments characterized by stiffness and lameness of a rheumatoid nature, and it may well be that some of these illnesses, if fully investigated, would prove to be swine erysipelas. It is to be hoped, therefore, that farmers will now be on their guard against this disease and will bear in mind its symptoms and post-mortem appearances. The laboratory staff will be glad to examine specimens from suspected cases and in particular to attempt to establish whether cases of "rheumatism" in pigs have any connexion with swine erysipelas.

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RAINFALL INTERCEPTION BY CYPRESS AND BAMBOO

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In May, 1946, an experiment was laid out in the Kikuyu Escarpment forest to compare the amounts of rainfall intercepted by the crowns of (*a*) cypress trees and (*b*) bamboos.

The comparative results for the first six months of the experiment are given in this note. The experiment is continuing. The site of the experiment is in the Kinale area on the Bamboo Forest road from Limuru to Kinangop at an altitude of 8,600 to 8,750 feet. This road climbs steadily from south to north, along the top of the watershed which cuts off the heads of the streams which flow eastwards from the steep slope into the Rift Valley. The prevailing wind blows from the east.

Two plots were laid out for the rainfall observations, one in a 20 year old plantation of Monterey cypress (*Cupressus macrocarpa*) and the other in virgin forest of bamboo (*Arundinaria alpina*) on the same ridge as the cypress plot and one mile from it.

The lay-outs and the positions of the rain-gauges in the plots were designed by Squadron-Leader W. A. Grinsted, Assistant Director of the British East African Meteorological Service. He also drew up the daily routine for measuring and recording the rainfall, and provided the 22 rain-gauges used in the experiment. His advice and assistance, together with that of the Director, Group Captain A. Walter, O.B.E., are gratefully acknowledged.

The method employed for comparing the rainfall in the open with the amount of rainfall penetrating to ground level is described below.

Rainfall in the open is measured by two gauges for each interception plot, each one placed in the centre of a clearing in the forest. The size of each clearing is such that the distance of the gauge from the edge of the clearing is twice the height of the surrounding trees or bamboos. The two clearings are in each case situated, one to windward and the other to leeward of the interception plot as shown in the diagram.

Penetration of rainfall and drip from the crowns of the trees is measured by a number of gauges set in the interception plot. In the cypress plot, which is 1 acre in extent, 12 gauges are used. Their positions were selected by the following method. A plan was prepared showing the exact position of each of the 225 trees in the plot, and each tree was measured and numbered. Twelve trees were then selected at random by means of Tippett's Tables of Random Sampling Numbers. The greatest distance between trees in the plot is 22 feet. A gauge was then placed near each selected tree, at a distance from it of 1, 3, 5, 7, 9 or 11 feet, so that each distance had two gauges representing it.

In the bamboo interception plot two groups of 3 gauges each, or 6 gauges in all, are used. In each group of 3 gauges, one gauge is set in the centre of a clump of bamboos, one on the edge of a clump, and one in the space between two clumps of bamboos.

Both in cypress plantations and in bamboo forest rain penetrates the canopy in three ways —direct penetration through gaps in the foliage, drip or splash from the foliage and branches, or by running down the stem. The gauges will catch direct penetration and drip but will not record stem run-off. The method used by Dr. C. L. Wicht, Forest Research Officer, at the Jonkershoek Research Station, Cape Province, to measure stem run-off in a stand of grey poplar (*Populus canescens*) described in the Journal of the South African Forestry Association (April, 1941) is being used in this experiment at Kinale. A strip of two-and-a-half inch lead sheeting is fixed in a descending spiral round the stem of the tree or bamboo at a convenient height (2–4 feet) from the ground, and moulded to form a small gutter. The edge of the gutter against the stem is then forced flush with the surface of the stem by prising it into any irregularities of the bark with a screw driver or similar tool. To make this easier in the case of the cypress the bark was smoothed off before attaching the gutter, but with the bamboos this was not necessary. The join was then made watertight with an asbestos-bitumen cement. The water running down the stem is caught in the guttering whose lower end discharges into a suitable container on the ground. A cypress tree 16 inches diameter at breast height (d.b.h.) may discharge up to 30 or 40 gallons from stem run-off in a shower of 2 inches of rain. A smaller tree discharges proportionately less, and a 3 inch bamboo only discharges about

half a gallon from a similar shower. The size of the container will therefore need to be suited to the size of the stem. In the Kinale experiment rectangular galvanized-iron tanks with lids, varying in capacity from 50 gallons to 10 gallons, are being used to catch stem run-off from the cypress trees. The tanks are graduated in 50-pint units by lines running round the inside of the tank. To get an accurate reading therefore the tank must be set level. Any surplus water between two graduations is first removed by dipping, and measured to the nearest pint.

Ten sample trees of cypress were selected as follows for measurement of stem run-off. The trees in the one-acre plot were tallied in breast-height diameter classes, and classified into four groups of equal basal area. Two sample trees were then selected in each group, their diameter at breast height corresponding as closely as possible to the mean diameter at breast height of the group. This gave eight sample trees for the purpose of calculation of stem run-off. Two trees of larger diameter were added, to facilitate the plotting of the upper portion of a curve for stem run-off against basal area.

In the bamboo plot eight bamboos were selected from among old and young culms, their size covering the range of diameters in such a manner that the mean of their basal areas corresponds to the mean basal area for the whole of the bamboos in the plot which had been previously tallied in diameter classes. Stem run-off is caught in empty 4-gallon oil tins (now found to be unnecessarily large) and is measured in the graduated rain gauge glass used for measuring the rainfall caught in 5-inch diameter gauges. The stem run-off measured thus in inches is converted to pints by multiplying by 0.283.

The measurement of rainfall and stem run-off and the care of the gauges and stem-gutters is carried out by an African Assistant Forester who was taught the job and supervised by a European Forester for the first two weeks of the experiment when rain fell on practically every day. A path is cleared from gauge to gauge so that the readings are made in the same order every day, this order corresponding to the order of the columns in the record book. The same applies to the stem run-off tanks. Each gauge and tank has its number painted on it. The plots are inspected daily and any rainfall recorded, starting at 8 a.m. When little or no rain has fallen the inspection is finished by 10 a.m., but on mornings when there is much water in the stem run-off tanks work may not be over until mid-day. If rain is falling at 8 a.m. measurement is postponed until it has stopped.

The results are calculated by the following methods:—

Rainfall is taken as the mean of the readings of the gauges in the two clearings, in inches of rainfall.

Penetration is taken as the sum of (1) direct penetration and drip, being the mean of the gauges in the interception plot, in inches of rainfall and (2) stem run-off, converted to inches of rainfall by the method described below for the cypress and bamboo interception plots.

(*a*) Cypress plot.

The trees in the 1-acre plot were tallied in 1-inch d.b.h. classes. The trees were then classified into four groups of equal basal areas, as in the standard method for calculating the volume of a stand of timber. As has already been said, the eight sample trees were selected to represent the mean basal areas of the groups, two to each group.

Stem run-off is then calculated for each basal area group separately, as in the following formula:—

$$S = \frac{B \times v}{b \times 22{,}623}$$

where S = inches of rainfall equivalent to the stem run-off as measured in volume; v = stem run-off in gallons of the two sample trees representing the group; B = total basal area of all the trees in the group; b = basal area of the two sample trees representing the group.

The sum of the values of S for the four groups gives the total stem run-off expressed in inches of rainfall, which is added to the readings for direct penetration and drip, in order to give total penetration of rainfall under cypress crowns.

(*b*) Bamboo plot.

In this plot the stem run-off in inches of rainfall is calculated from the actual volume of stem run-off of the sample bamboos by the same formula as that given above for the cypress plot, except that the calculation is made for

the whole plot instead of by groups. In the formula—

$$S = \frac{B \times v}{b \times 22{,}623}$$

therefore B equals the basal area of the stems on 1 acre of bamboo and b equals the basal area of the eight sample bamboos, v being equal to their total stem run-off in gallons.

The results are shown in tabular form below:—

Summary of Results

During the first six months of the experiment 17.2 per cent of the total rainfall was intercepted by the crowns of the cypress trees, as compared with 13.4 per cent by the foliage of the bamboos.

The amount of rain which penetrated the crowns in the form of stem run-off was small, being 3.1 per cent of the total rainfall in the cypress plantation and 2.5 per cent in the bamboo forest.

INTERCEPTION OF RAINFALL IN A CYPRESS PLANTATION COMPARED WITH BAMBOO FOREST.

Month.	Rainfall	Direct Penetration and Drip.		Stem Run-off		Total Penetration.		Inter-ception.
	ins.	ins.	%	ins.	%	ins.	%	%
Cypress Plantation—1946								
May	8·71	7·18	82·4	0·26	3·0	7·44	85·4	14·6
June	0·82	0·57	69·5	—	—	0·57	89·5	30·5
July	0·32	0·23	71·9	—	—	0·23	71·9	28·1
August	2·26	1·77	78·3	0·04	2·0	1·81	80·3	19·7
September ..	4·61	3·70	80·2	0·20	4·4	3·90	84·6	15·4
October	5·65	4·38	77·5	0·21	3·5	4·59	81·0	19·0
Totals ..	22·37	17·83	79·7	0·71	3·1	18·54	82·8	17·2
Bamboo Forest—1946								
May	7·00	5·83	83·3	0·14	2·0	5·97	85·3	14·7
June	0·67	0·50	74·6	—	—	0·50	74·6	25·4
July	0·36	0·27	75·0	—	—	0·27	75·0	25·0
August	2·62	2·24	85·5	0·04	1·5	2·28	87·0	13·0
September ..	5·30	4·44	83·8	0·17	3·2	4·61	87·0	13·0
October	5·36	4·64	79·2	0·19	3·2	4·83	82·4	17·6
Totals ..	21·31	17·92	84·1	0·54	2·5	18·46	86·6	13·4

Rainfall readings (1·97 in.) for 1st and 2nd May were not included.

REVIEWS

ELEMENTS OF TROPICAL SOIL SCIENCE by T. Eden, D.Sc., Macmillan & Co., London, 1947, 136 pp., price Sh. 5.

In this small book Dr. Eden has described in simple language what soil science is and what it means to the planter. He has not made it sound easy by omitting the fundamental theories and the technical applications, but he has made these as readable as possible by careful explanations. Anyone who picks up the book casually on a wet afternoon in order to "learn all about soil" may be disappointed, but after a few wet afternoons he will begin to look on his soil with a different eye.

The author has achieved his purpose; to give practical men an opportunity of learning the elements of soil science with the minimum of effort. He does not tell farmers how to make more money with less work, but he gives them an opportunity of working out the meaning of many puzzling observations which they may have thought could only be due to the perversity of nature. Agricultural officers will find in this book a refresher course which will recall many lectures which they have forgotten, and administrative officers who read it will understand the reasons for some native agricultural practices.

Some parts of the book deserve special praise. It is not easy to explain clearly and simply the theories of soil moisture, base exchange, pH and soil organic matter, but this has been done very well. A chapter on statistical field trials has also been included, which explains how information of great practical value can be obtained from small-scale experiments.

Agricultural officers sometimes find it difficult to explain to farmers the technicalities of their work, but this book will make it easier for them to discuss the theoretical aspects of practical problems. For this reason, amongst others, the book should be a great asset to all who are interested in tropical agriculture.

D.W.D.

LES LOTISSEMENTS AGRICOLES DU NORD-SANKURU by A. Brixhe. Published by Le Centre d'Etude des Problèmes Sociaux Indigènes, Elisabethville, Congo Belge.

This booklet is appropriately issued as the first publication of the Centre d'Etude des Problèmes Sociaux Indigènes, for as is stated in the introduction, the problem of agricultural settlement is not only, or even primarily, an agricultural but a social one. The author, however, is an agronomist in the service of the Compagnie Cotonnière Congolaise, and he describes a method of agricultural settlement which has been a success in one region of the Congo and is offered as an example which might be of help to planners elsewhere, though it is repeatedly emphasized that the details of the method have been worked out for one set of conditions only.

This work has been done in the North Sankuru District of the Lusambo Province, an area almost in the centre of the Belgian Congo, and where, as throughout the central Congo basin, the conditions are difficult for East Africans to visualize. The background is a scene where the natural cover consists wholly of high forest; yet this exists on a poor sandy soil by virtue of a cycle in which fertility is only maintained by the decay of material from the forest itself. The urgent problem is that after clearing the forest, under regular cultivation it is not long before the inherent fertility is destroyed and yields of crops become uneconomic; when abandoned under these conditions, the soil is too poor to regenerate forest, and will only develop a sparse tussocky grass cover which does nothing to restore fertility. Faced in increasing numbers with the prospect of gradual starvation, the only alternative known to the peasants is the laborious clearing of further stands of the best forest, only to reduce these in turn to the same condition. The social disadvantages of the scattering of the clearings of single cultivators or small groups through vast areas of forest are also emphasized.

The first step towards a solution was to devise a rotation which under these conditions was capable of maintaining a permanent equilibrium. Here it must be remembered that throughout the central Congo basin, the agronomist thinks in terms of a long-term forest fallow, where we think of short-term grass fallows. The rotation finally decided on, with the advice of the experts of I.N.E.A.C. (but surely it will take a long time to prove whether it is the right one!) was five years of cultivation, followed by 15 years of forest regeneration before cultivation begins again.

On such a basis the scheme was planned. An arduous reconnaissance survey of vast tracts of forest had to be carried out to find the most

suitable large continuous areas on which holdings could be placed. This task evidently taxed the available staff to the utmost, and could not have been carried out without the backing of two of the big cotton companies, who seem to have borne the brunt of the whole work. In the majority of cases, it was possible to site the blocks within reasonable distance (up to six kilometres) of existing villages; in these cases there was no necessity for new building, at least immediately. Under these conditions, the best English equivalent of the word "lotissements" would appear to be "agricultural settlement".

Elsewhere, where it was necessary to move populations and build new villages, we should call it "re-settlement". Wherever possible, the settlement blocks were placed near to existing roads; but in some cases where conditions of soil or topography made this impossible, a corresponding amount of road-building was of course necessitated.

The lay-out of the settlement blocks is sufficiently interesting to be described in some detail. A base-line is first marked out in the forest, between 800 and 2,000 metres in length according to the size of block desired. Along this line, sections of variable width for each scheme, but not less than 40 metres, are allocated to each cultivator. This gives him the front along which he will advance his holding into the forest, to an equal depth each year. In the first year, each cultivator is expected to clear from forest and to cultivate an area of 40 *ares* (=0.98 acres); by doing the same for five successive years, his cultivated area attains its full size of two hectares (4.94 acres). Great stress is laid on all cultivators keeping up to the same common frontage each year, and to insist on this is one of the chief tasks of the supervisory staff. The clearing eventually attains a depth of twenty annual sections of forty *ares* each, after which the cultivator returns to the cultivation of his first section, which has now been 15 years under forest fallow. The rotation adopted throughout the schemes has been the following:—

Year.	*Crop.*
1 ..	Rice, interplanted with cassava.
2 ..	Rice.
3 ..	Cassava.
4 ..	Cotton, followed by groundnuts or millet.
5 ..	Cassava.
6–20 ..	Natural regeneration of forest.
21 ..	Recommence rotation as in year 1.

This rotation requires some explanation. The rice of the first year is interplanted with cassava where any gaps occur in the sowing on the newly-cleared land; but after the rice harvest, the whole plot is planted with cassava. In the following rainy season the cassava stems are cut back and the second rice crop planted; by the time the rice is harvested, the cassava is again springing up. The cassava in the fifth year is planted as a nurse crop for the young forest re-growth. The object in all these cases is to maintain a constant cover over the soil, with only minimum periods when it is bare; this is regarded as a most important measure against erosion, and is apparently the only one that is thought necessary under North Sankuru conditions.

The forest fallow growth consists mainly of quick-growing and shrubby forms, among which are mentioned *Musanga Smithii, Caloncoba, Trema, Vernonia* as the chief.

At irregular intervals according to the terrain there are left narrow blocks of uncleared forest stretching the length of the holdings and separating one group from another. These are designed as reserves to give some elasticity to the dimensions laid down, in case it is wished to adjust these at some later date, fit in an extra holding, or compensate for a piece of infertile ground which cannot be cultivated. One presumes that these internal reserves also have some effect as wind-breaks and as seed-suppliers for the forest regeneration period.

Such are the bare bones of the settlement scheme. In implementing it, a number of minor problems arose, which are fully discussed by the author. Suffice it here to say that two years of experience have in the author's opinion proved the scheme to be a practicable working one for the district concerned. Crop yields in some of the settlements have proved to be very greatly higher than those obtained by the same cultivators under their previous methods on worn-out land.

While the whole scheme has been carried out with the blessing of the territorial administration, it is emphasized that so far no legal sanctions have been applied, and all movements have been voluntary. In fact, in some of the settlement areas a number of applications for holdings have come in from men who were not originally included. This gratifying result is perhaps to be related to the very low level of fertility to which much of the existing cultivated land had fallen. A certain degree of elasticity is also wisely permitted in the settlements, since each cultivator who wishes to do

so may cultivate extra land outside the block in which he has an allocated holding, though it is reckoned that the latter will suffice a family for food and cash crops.

The author is not slow to point out the social as well as agricultural advantages arising from such grouped cultivation. Administration and health work is obviously made easier, as is also crop inspection, provision of roads and water supplies and many other factors. In fact it is claimed that many of the advantages of collective farming are potentially available, while individuality of tenure is preserved. The full numbers of cultivators in the settlement schemes is not given, but blocks containing in total 1,650 heads of households are referred to.

We are grateful for this detailed description of an operation which, whatever degree of perfection it may ultimately be found to possess, is the fruit of careful planning and much hard work. There is no territory in East Africa which is not faced with similar problems and has not to consider re-settlement schemes; the Kigezi scheme in Uganda, and re-settlement in tsetse areas spring at once to mind. The more exchange of information between territories by publication the better.

Suffering under our own burdens, it is perhaps a comfort to know that in the Belgian Congo too, the staff of the Government agricultural service have too little time for field work because they are "so often, alas, transformed into bureaucrats"!

G. B. MASEFIELD.

THE BAMBOO BORER (DINODERUS Sp.)

For the last fifteen months, since the institution of the Kenya Forest Department Entomology Section a strict look-out has been kept on the Bamboo Borer. Bamboo being such a widely used material, one would expect the beetle to be found everywhere. On the contrary, here in Kenya, its presence appears to be quite sporadic. Enclosures fenced with Bamboo, military quarters with indoor structures of bamboo, and other similar bamboo structures, have often shown no trace of infestation whatsoever in either new or old material, but on the other hand, an occasional hut may be found, far from other habitation, with the roof rapidly collapsing. This would lead us to expect that the insect originated in occasional bamboo culms brought from the extraction area, a theory which may yet prove to be true, but to the present date we have never found the beetle in bamboo forest. However this may be, it does not appear worth while systematically to treat all bamboos prior to marketing. In other parts of the world (notably in India, for the protection of tent poles) treatment with various preservatives has been tried, using both water-soluble salts and other preserving agents such as creosote. Holes have to be bored between each node to allow entry, but where split bamboo is used the process is, of course, much simpler. In addition to this, many experiments have been done on the world-wide and time-honoured principle that bamboo felled at certain seasons is more immune from beetle attack than that felled at others. Impregnation with chemicals dissolved in paraffin is expensive, and water-soluble salts (except for use in seasoned bamboo) are not to be recommended on account of the splitting that occurs in the subsequent drying. In all, it appears that soaking split bamboos in plain water for two months or more is the best method, a treatment discovered from the fact that bamboos used for rafts were found to be immune.

Although it has been said above that the general treatment of all bamboo is probably not warranted at present in Kenya, the principles of bamboo preservation are here discussed because we have discovered, in Nairobi, that the Bamboo Borer is taking to eating ply-wood in the factory, split bamboos having been used to separate the stacked ply-wood sheets. In this case the ply was made of Mwafu, a light and large dimensioned timber from Jinja, Uganda. In such a case it would be well worth while treating the bamboo used for this purpose.

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